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THREE STYLISED SCENARIOS

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Potential Impact of Dietary Changes on the Triple Challenge Facing Food Systems: Three Stylised Scenarios

Grégoire Tallard, Marcel Adenäuer, Koen Deconinck, and Gaëlle Gouarin

A shift towards healthier diets is expected to address the challenge of providing food security and nutrition for a growing global population. This report explores whether such a shift would also have positive effects on the other two challenges food systems face: supporting livelihoods for those working along the food supply chain and contributing to environmental sustainability. The report finds that aligning diets with World Health Organisation guidelines on sugar and fat consumption would have the expected positive effect on nutrition and food security, and would also positively affect environmental sustainability. The effect on livelihoods along the food value chain, however, would overall be negative. The magnitude of the trade-offs and synergies are greater when fat consumption is reduced, as opposed to sugar consumption, because actual consumption levels of fat are further away from WHO recommendations.

Keywords: Dietary recommendations, Food security, Sustainability, Undernourishment, Overweight

JEL codes: C53, I10, Q01, Q02, Q54

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Abbreviations and acronyms

ADER	Average Dietary Energy Requirement (kcal/person/day)
ASF	African Swine Fever
BMI	Body mass index (kg/m2).
CV	Coefficient of variation parameter
DEC	Dietary Energy Consumption (kcal/person/day)
DEI	Dietary Energy Intake (kcal/person/day)
FAO	Food and Agriculture Organisation
FSIs	Food Security Indicators
GHGs	Greenhouse gases
HFCS	High-fructose corn syrup
Kcal	Kilocalories
LULUCF	Emission associated with Land Use, Land-Use Change and Forestry sector
MDER	Minimum Dietary Energy Requirement threshold to become undernourished (kcal/person/day)
$MtCO_2$-eq	Million tonnes CO_2-equivalent
POOV	Prevalence of Overweight (%)
POOB	Prevalence of Obesity (%)
POU	Prevalence of Undernourished (%)
SDG	UN Sustainable Development Goals
SK	Skewness parameter
XDER_OB	Maximum Dietary Energy Requirement threshold to become obese (kcal/person/day)
XDER_OV	Maximum Dietary Energy Requirement threshold to become overweight (kcal/person/day)
WHO	World Health Organisation

What is the issue?

Various measures have been proposed to meet the challenge of feeding a growing world population in a sustainable way. Each of these will have implications for the ability of food systems to address the triple challenge of providing food security and nutrition, providing livelihoods to those along the food supply chain, and contributing to environmental sustainability. Using three stylised scenarios, this report explores some of the potential medium-term global impacts on food systems that reductions in free sugar[1] (hereafter "sugar" or HFCS) and fat[2] consumption could have. It also highlights the synergies and trade-offs of the different approaches used.

Methodology

The AGLINK-COSIMO model and associated indicators are used to estimate the potential impacts of aligning global diets with World Health Organisation (WHO) guidelines on sugar and fat consumption. The model extensions developed for this work offer a unique framework to provide forward-looking information on the different dimensions of the triple challenge. Indicators highlighting various impacts across the triple challenge provide a partial view[3] of the potential synergies and trade-offs.

What did we learn?

The stylised scenarios highlight the following.

- Achieving WHO's recommended sugar and fat consumption targets would have a positive impact on the nutrition and food security dimension of the triple challenge and on the sustainability dimension (synergy), but a negative impact on the livelihood dimension (tradeoff).
- The magnitude of the trade-offs and synergies are greater when fat consumption is reduced, as opposed to sugar consumption, because actual consumption levels of fat are further away from WHO recommendations.
- Dietary changes would have distributional effects as some regions might gain or lose more than others on certain dimensions. This results from the various synergies and trade-offs are related to production and consumption patterns.
- The results suggest that food policies should take into consideration health issues, farmers livelihoods, and agricultural outcomes in order to be beneficial to agriculture, sustainability, nutrition, and food security.

Notes

1. The model does not consider processed foods, whereas most of the foods we consume are processed to some degree. It only considers impacts related to agricultural production/consumption rather than the full food supply chain which would include livelihoods and products further along the food supply chain, including processing, distribution and disposal.
2. In particular, saturated fats (found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee and lard).
3. The "partial view" on potential synergy and trade-offs are due to model limitation discussed in Part 2.

1. Introduction

Global diets have changed substantially over the past 50 years, with people increasingly consuming more resource-intensive, calorie-dense foods, such as animal products and processed foods (Aleksandrowicz et al., 2016[1]; Popkin, 2017[2]). This increase in calorie availability in Kcal/day/capita is seen in both developed and developing countries, although calorie availability remains stagnant in many countries, particularly in Africa. Since 1960, the global average per capita supply of vegetable oils and meat has more than doubled, while the supply of food calories[1] per capita has increased by about one-third (IPCC, 2019[3]). These changes include not only a shift towards higher food energy supplies, but also towards more fats and oils and more animal-based foodstuffs, resulting in higher intakes of saturated fat and cholesterol (Schmidhuber and Shetty, 2005[4]). While these shifts in consumption patterns reflect rising incomes and increased food access, it has implications for the triple challenges faced by global agriculture and food systems: namely – in terms of its impact on food security and nutrition – on the livelihoods of those along the food supply chain, and on environmental sustainability (OECD, 2021[5]).

Changes in dietary patterns have contributed to a double[2] burden of malnutrition. In 2016, more than 1.9 billion people were overweight; of these, over 650 million were obese (WHO, 2020[6]). Yet, the world also continues to struggle with undernourishment; the FAO's *State of Food Security and Nutrition in the World 2020* (FAO et al., 2020[7]) estimates that nearly 690 million people were undernourished in 2020. Undernourishment and overnourishment lead to a wide range of nutrition-related problems. When a person is undernourished, the lack of essential nutrients leads to, for example, wasting (low weight-for-age) and stunting (low height-for-age) which in turn can lead to lifelong impairment in cognitive development. On the other hand, the impact of overnourishment can lead to overweight and obesity, in turn leading to poor health and often lower life expectancy (OECD, 2019[8]). Unhealthy diets associated with overnourishment – even in cases where this does not result in overweight or obesity – present the biggest risk factor for non-communicable diseases (NCDs), such as Type 2 diabetes and cardiovascular diseases (Branca et al., 2019[9]).[3] Undernourishment and overnourishment also carry negative economic consequences, such as lower labour market productivity, higher health expenditures, and increased taxes; all contribute to lower Gross Domestic Product (GDP) and incomes (OECD, 2019[8]).

Population growth and increased per capita consumption of food are also associated with increased environmental risks and degradation, including the increased emission of greenhouse gases (GHGs) (OECD, 2021[5]). While increased productivity has made it possible to meet demand using less land than would otherwise have been the case and to a decrease in emissions intensity of production, overall agricultural land use remained constant and direct GHG emissions from agriculture increased.

Current dietary trends, combined with a world population that is projected to reach 10 billion people by around 2050, will exacerbate risks to both people and the planet. Conversely, changes toward healthier diets and more sustainable food systems could contribute to achieving the UN Sustainable Development Goals (SDGs), Goal 2 in particular, and the Paris Agreement (Willett et al., 2019[10]). In particular, dietary guidelines at both the national[4] and the global levels recommend consuming a variety of foods, including

[1] In this paper, kilocalories and calories will be used interchangeably.

[2] An additional burden associated with malnutrition, micronutrient deficiencies, is not part of this analysis.

[3] While overnourishment is the most important (but not only) factor underpinning overweight and obesity, it will be used interchangeably in this paper.

[4] http://www.fao.org/nutrition/education/food-based-dietary-guidelines.

fruits and vegetables, legumes, and animal-source foods (meat, eggs, dairy, fish), while limiting the intake of sugar, fat and salt. Shifting global diets away from current consumption patterns to be more in line with these guidelines could have important implications for the triple challenge facing food systems.

This report provides an initial quantitative assessment of the potential impact of such dietary shifts on several indicators of the triple challenge – namely food security and nutrition, livelihoods, and environmental sustainability. It draws on a set of three stylised medium-term scenarios that explore the potential impacts of aligning global diets with the World Health Organization (WHO) guidelines, which recommend that in a balanced diet free sugars should consist of no more than 10% of total calorie intake, while fats should consist of no more than 30% of calorie intake (World Health Organization, 2015[11]; World Health Organization, 2018[12]). The results of this stylized exercise should be regarded as indicative; they demonstrate how each dimension of the triple challenge could be affected by this dietary shift, as well as the possible synergies and trade-offs between those dimensions.

Section 2 describes the Aglink-Cosimo model used in the simulations (hereafter "the model"), the baseline, the selected indicators of the triple challenge, and some of their limitations. It sets the scene by describing the evolution of key dimensions of the triple challenge over the coming decade, using the *OECD FAO Agricultural Outlook 2020-2029* baseline as a reference (hereafter "the baseline"). Section 3, outlines this report's stylised scenarios. Section 4, describes the results of each scenario, and Section 5 compares synergies and trade-offs across the scenario results.

Box 1. The OECD-FAO Aglink-Cosimo model of global agricultural markets

Aglink-Cosimo is an economic model of global agricultural markets which can be used to analyse supply and demand of major agricultural commodities, as well as biodiesel and ethanol. It is managed by the Secretariats of the OECD and the Food and Agriculture Organization of the United Nations (FAO). The model is used for scenario analysis and to generate the annual *OECD-FAO Agricultural Outlook* (OECD/FAO, 2020[13]).

Aglink-Cosimo is a recursive-dynamic partial equilibrium model used to simulate development of annual market balances (production, consumption, exports, imports and stocks) and prices for major agricultural commodities: cereals (maize, wheat, rice and other coarse grains), oilseeds and oilseed products (protein meal and vegetable oil), sugar, meat (beef and veal, poultry, pigmeat, and sheepmeat), dairy (fresh dairy products, cheese, butter and milk powders), biodiesel, ethanol, cotton, pulses, and roots and tubers.[1] As a recursive-dynamic model, outcomes for one year influence those for the following years (e.g. through herd size dynamics). The model's level of detail, as used in this report, required several extensions to the commodity coverage included in the *OECD FAO Agricultural Outlook* report, but makes it possible to calculate derived indicators, such as per capita calorie or protein intake, food expenditures, or direct agricultural emissions.[2]

The model has a global coverage (Annex E).[3] World markets for agricultural commodities are assumed to be competitive, with buyers and sellers acting as price takers. Market prices are determined through global and regional equilibrium in supply and demand. Domestically produced and traded commodities are assumed to be perfect substitutes from the point of view of buyers and sellers. However, the model elasticities do not account for isocaloric compensation with other agricultural commodities. This implies that consumers do not have food calorie targets and likely over- or underestimate market impacts of shocks in food markets. Aglink-Cosimo includes exports and imports, but does not track bilateral trade flows.

The model treats non-agricultural markets as exogenous and gathers macroeconomic variables from other sources. The model does not incorporate feedback from agricultural market developments to the economy as a whole (in contrast with computable general equilibrium models) which may be important in regions where agriculture is an important share of economic activity.

More information (including detailed model documentation of Aglink-Cosimo) is available at www.agri-outlook.org.

Notes

1. The model does not consider processed foods which account for 30% of food consumption.

2. Which exclude emissions from land-use and deforestation and doesn't include linkage and spillover to other economic sectors.

3. Specifically, the Aglink component of the model consists of 14 modules: ten OECD countries and regions (Australia, Canada, European Union (EU), Norway, Japan, Korea, Mexico, New Zealand, Switzerland, United Kingdom and the United States) and four non-OECD countries (Argentina, Brazil, China and the Russian Federation). The Cosimo component of the model completes the world coverage and consists of 42 endogenous modules: three OECD countries (Chile, Israel and Turkey), a further 27 single countries, and 12 regional.

2. The world in 2030: Baseline and indicators of the triple challenge

All scenarios included in this report are evaluated using the Aglink-Cosimo model of global agricultural markets (Box 1). The scenarios are compared to the baseline projections for global agriculture in 2030, which is derived by extending the baseline 2020-2029 by one year to 2030. The baseline uses the same assumptions as the *OECD-FAO Agricultural Outlook 2020-2029* (OECD/FAO, 2020[13]) in terms of demographic trends, macroeconomic variables, average weather conditions, and unchanged policy settings.[5]

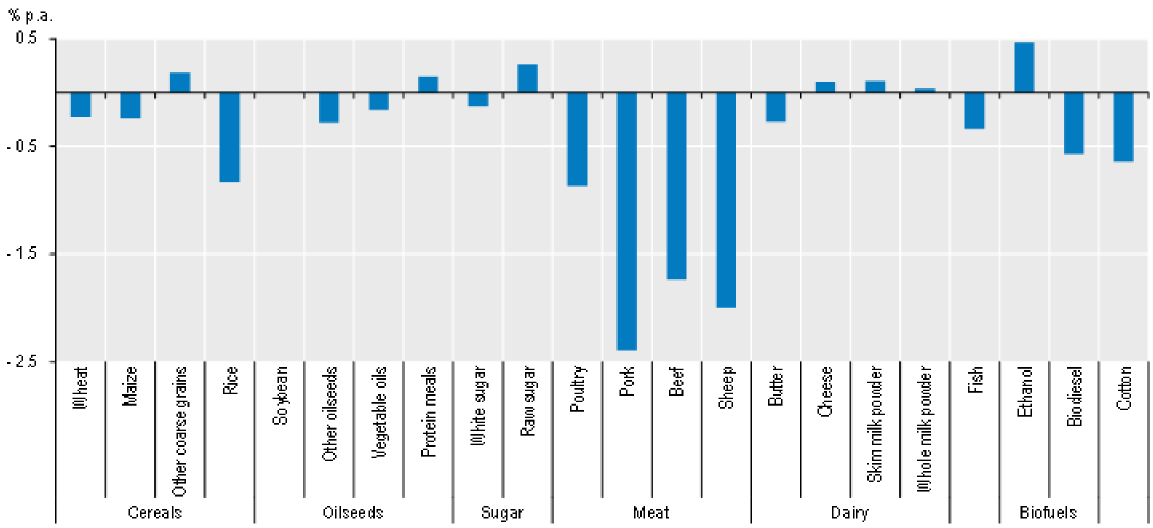
This section highlights the main expected trends in global and regional agricultural markets up to 2030, as well as the projected evolution of key indicators capturing the different dimensions of the triple challenge. More detailed discussions of these trends, as well as various risks and uncertainties, can be found in the *OECD-FAO Agricultural Outlook 2020-2029.*

Global agriculture, 2020-30: Main trends

For most of the commodities covered in the *Outlook*, the baseline projections show real prices declining at a rate of less than 2.5% per year over the coming decade (Figure 1). This reflects the expectation that the current trend in productivity growth for these commodities will continue over the coming decade. Declining prices are consistent with long-term trends for agricultural commodities, although the historical record also shows short-term periods of volatility and high prices. As the baseline projections focus on structural trends, they exclude short-term shocks, such as harvest failures or demand shocks, which could lead to such volatility. Over the coming decade, meat prices are projected to decrease more strongly, partly as a reflection of their current high levels, while crops prices will experience a more modest decline.

[5] While the baseline exogenous assumptions impact the outcome of the baseline itself, the results of the stylized scenarios should not be significantly impacted by that initial choice of exogenous assumptions because model elasticities are mostly driving the results.

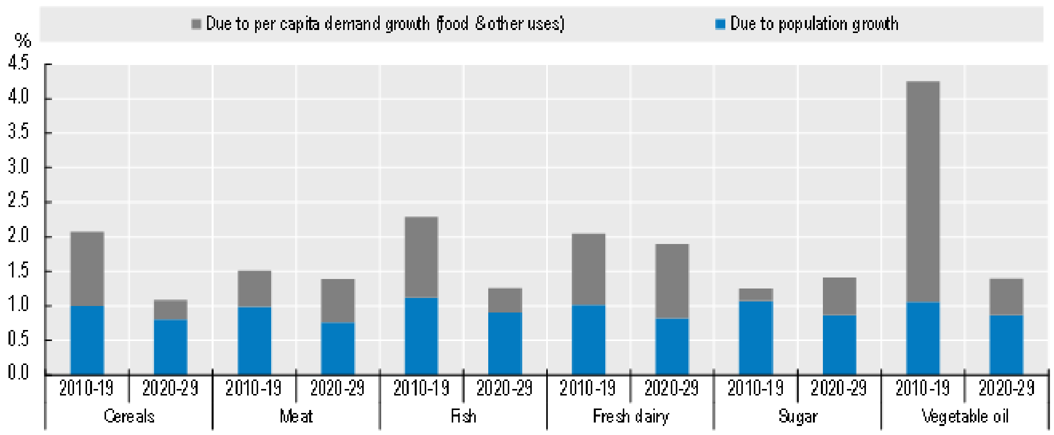
Figure 1. Average annual real price change for agricultural commodities, 2020-29



Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Global demand for agricultural commodities experienced strong growth in the first 10-15 years of the 21st century. While food demand stagnated in the developed world, biofuel policies spurred demand for maize, sugarcane and vegetable oils as biofuel feedstock. In parallel, rising incomes in the People's Republic of China (hereafter "China") and other emerging economies stimulated demand for meat, which in turn boosted demand for animal feed. While these factors are expected to continue to play a role in global demand for agricultural commodities, their relevance is expected to diminish over the projection period of 2020-30. Moreover, these factors are not expected to be replaced with comparable sources of demand growth (Figure 2).

Figure 2. Annual growth in demand for key commodity groups



Note: The population growth component is calculated assuming per capita demand remains constant at the level of the year preceding the decade. Growth rates refer to total demand (for food, feed and other uses).
Source: OECD/FAO (2020), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

Per capita food consumption of many commodities is expected to be almost flat at the global level over the projection period. This is true not only for staples such as cereals, but also for meat and fish. Several factors play into these expectations. In China, consumption of meat and fish has already reached high levels. In Sub-Saharan Africa, incomes are expected to remain low over the projection period, limiting the scope for per capita consumption growth. In India, where income growth is expected to be stronger, dairy is the preferred source of animal protein.

With the exception of fresh dairy products, food demand growth rates for most commodities are projected to be considerably below those seen in the previous decade. Global per capita food demand growth is expected to be strongest for fresh dairy products (spurred by growth in India) and vegetable oils (partly due to growing urbanisation in developing countries and a subsequent increase in demand for processed foods). Global demand for animal feed is expected to outstrip meat production, indicating a need for further intensification of the global livestock sector.

Expansion of agricultural production is expected to be most pronounced in Africa, India, and Latin America and the Caribbean, with more muted growth in the rest of the world. Despite the projected increase in global agricultural production, global agricultural land use is projected to remain broadly flat. Growth in crop production is thus expected to stem mostly from higher yields, although increased agricultural area will play an important role for soybeans and other oilseeds.

Currently, North America and Latin America are large exporters of agricultural commodities, while Africa and China are large importers. Over the projection period, Latin America is expected to increase its net exports and Africa is expected to increase its net imports. However, in line with the overall slowdown of demand for agricultural commodities, agricultural trade is expected to grow more slowly over the projection period.

The indicators used to represent the triple challenge provide more detailed insights on trends and developments assumed in the baseline.

Indicators of the triple challenge

Food systems face the triple challenge of providing food security and nutrition to a growing population, providing livelihoods to those along the food supply chain, and contributing to environmental sustainability (OECD, 2021[5]). The following indicators (selected on the basis of the information available from the extended model output) were chosen to shed light on different dimensions of this triple challenge (Table 1). These indicators simplify the discussion below by focusing attention on a limited number of key outcomes at the regional level.

Table 1. Indicators of the triple challenge

Challenge	Indicator	Definition	Coverage
Food security and nutrition	Sugar intake	Global per capita sugar intake	Global
	Fat intake	Global per capita fat intake	Global
	Calorie intake	Global per capita calorie intake	Global
	Protein intake	Global per capita protein intake	Global
	Food expenditures	Index capturing changes in food expenditures (at retail prices)	Global
	Undernourishment and overnourishment	Prevalence of undernourishment (PoU), Prevalence of overweight (PoOV), Prevalence of obesity (PoOB)	Global
Livelihoods	Agricultural revenues	Index capturing changes in agricultural revenues	Global
Environmental sustainability	Direct emissions	Direct GHG emissions from agriculture	Global
	Land use	Land use change	Global

Notes: See detailed descriptions in the text.

While these indicators capture important aspects of the triple challenge, it needs to be emphasised that they offer only a partial view because of data and evidence gaps, a phenomenon which holds for food systems more broadly (Deconinck et al., 2021[14]). For some dimensions, such as the livelihoods of those involved in the food system outside of primary agricultural production, sufficient data are not available to derive meaningful indicators. For example, the current framework measures the effects on agricultural producers' gross revenues, which on average represent 27% of consumer expenditure on foods consumed at home and a lower percentage of food consumed away from home (Yi et al., 2021[15]). It does not include indicators for wages or employment along the entire agricultural value chain, nor does it cover other non-agricultural segments of the food chain. For other dimensions, data sources may exist but are not yet embedded in the model and the baseline. This is the case, for example, for measures of biodiversity impact, and emissions related to land use, water use and pollution. In addition, many of the indicators in Table 2 are at the global level in order to allow for comparisons between scenarios at an aggregate level, which may hide important regional and national variations.[6] Several analyses examine in more detail the impact of dietary changes at the regional and national levels. The results are limited to one or two elements of the triple challenge; e.g. environment and health (see, for example, Geibel, Freund and Banse (2021[16]) and Esnouf, Russel and Bricas (2013[17]). Although further analysis of the triple challenge at the national level would help to assess synergies and trade-offs resulting from dietary changes, this would require additional investment in developping disaggregated indicators.

Other parameters included in the model may suffer from weak methodological underpinning which impact the analysis of synergies and trade-offs and the level of intervention needed, e.g. food waste estimates (Gustavsson and Cederberg, 2013[18]).[7] For example, Buzby, Wells and Hyman (2014[41]) estimate that consumers in the United States waste 22% of meat, while studies undertaken by Gustavsson and Cederberg, (2013[18]) estimate this waste to be at only 11%, assuming similar losses as those from UK households. Another weakness relates to the average commodity conversion factor into nutrients that is used to measure, for example, fat and sugar content. These and other weaknesses imply that there could be a considerable error in the estimates of consumption, as can be seen in Table 2 (see Range column). Moreover, a large share of consumption is composed of processed food, for which the standard amount of fat and sugar is very different from that associated with single commodities (e.g. wheat products).

Despite these shortcomings, the indicators presented in this report capture broad global trends and illustrate some of the synergies and trade-offs. They provide a quantitative angle for multi-dimensional approaches to estimate interlinkages and trade-offs between food choices, agricultural systems, economic, environmental and public health objectives that have been identified as important in analysing the effects of dietary changes (Geibel, Freund and Banse, 2021[16]) (Auestad and Fulgoni, 2015[19]).

Changes in key indicators for the baseline are presented in terms of the total growth between 2020 and 2030. In the rest of this section, indicators for the scenarios are expressed in terms of the difference between the scenario outcome and the baseline projection for 2030, unless otherwise noted.[8]

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[6] A proper comparison of regional or national level results would constitute a full-length report in itself. Instead, this report served to present a general indication of an array of synergies and trade-off pertinent to dietary changes on the triple challenge.

[7] Loss coefficients are estimated on the basis of existing data and literature, or based on assumptions when data gaps were to be filled. These are then assigned to each country group, by commodity group and by activity in the food supply chain. Waste estimates are in many cases based on assumptions and are not direct estimates or measurements (Bagherzadeh, Inamura and Jeong, 2014[44]; Gustavsson and Cederberg, 2013[18]).

[8] To avoid situations in which short-run fluctuations lead to misleading growth rates, all figures refer to three-year averages. Thus, growth rates over the past decade refer to growth between the average values for 2008-2010 and the average values for 2018-2020 under the baseline; growth rates over the coming decade refer to growth between 2018-2020 and 2028-2030. Data for 2018-2020 always refer to the baseline, including when growth rates for various scenarios are discussed, in order to have a fixed reference point.

Table 2. Share of fat content as a proportion of the total dry matter in the product (%)

Range among Aglink-Cosimo model countries and regions

	Range
Beef and veal	[20-72]
Poultry meat	[40-70]
Sheepmeat	[55-78]
Pigmeat	[73-88]
Eggs	[60-64]
Butter	[90-100]
Cheese	[73-92]
Fresh dairy products	[35-68]
Vegetable oil	[99-100]

Note: The dry matter of food includes carbohydrates, fats, proteins, vitamins, minerals, and antioxidants.
Source: FAO.

Food security and nutrition

The indicators for food security and nutrition include the following[9].

- *The global average calorie and protein intake per capita*: Per capita calorie and protein intake refer to average values and reflect overall food availability which is reduced to account for food waste (Table 1).
- *A food expenditure index (which captures changes in the retail cost of food)*: The food expenditure index provides an indication of the evolution of food affordability, for which food price variations are a contributing factor, and provides information on households' access to food[10] (Table 1).
- *The prevalence of undernourishment*: Undernourishment is defined as "the condition of an individual whose habitual food consumption[11] is insufficient to provide, on average, the amount of dietary energy required to maintain a normal, active, healthy life" (FAO, 2019[20]). The prevalence of undernourishment (PoU) is an indicator determined, among other factors, by the distribution of Daily Energy Consumed (DEC) in a country (Cafiero, 2014[21]).
- *The prevalence of overnourishment*: Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2020[6]), akin to the concept of over-acquisition which is "the condition of individuals in a population who tend, on a regular basis, to acquire food in excess of their needs" (Cafiero, 2014[21]) after taking into account food waste. Using WHO historical data, the indicators of prevalence of overweight (PoOV) and of prevalence of obesity (PoOB) are based on a methodology adapted from that of PoU and are determined, among other factors, by the distribution of Daily Energy Intake (DEI) in a country (Table 1). Overnourishment is determined by several factors other than calorie intake. However, overnourishment remains an important risk factor for overweight and obesity. The indicators developed here are based on trends of their historical values to measure "high" and "very high" levels of calorie intake, as risk factors for overweight and obesity, respectively.

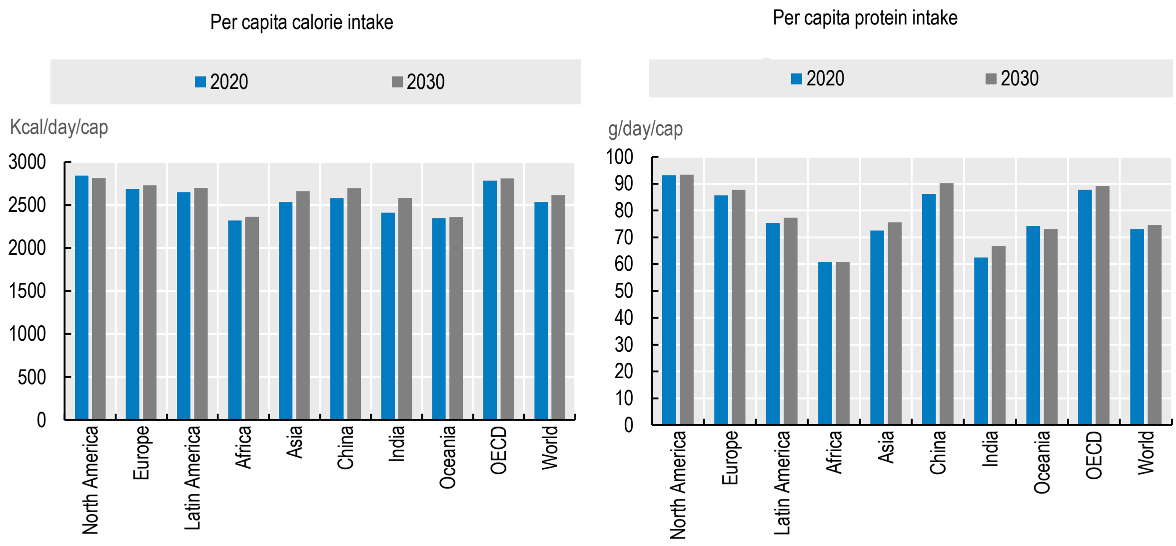
[9] See Annex A for more details on the methodology for under and overnourishment estimates.

[10] Fluctuations in food prices in real terms have had significant impact on the proportion of average income devoted to the purchase of food.

[11] In particular, access to traditional staple foods which have a significant impact on nutritional intake of poorer individuals.

In the baseline projection, global per capita calorie intake is expected to rise by a total of 3% to 2 615 Kcal/day/capita by 2030, while per capita protein intake is projected to grow by 2% (Figure 3). Growth rates are highest in China (calories +4.5% and protein +4.7%) and India (calories +7.2% and protein +6.8%) (Figure 3). In India, higher projected growth rates are linked to growing consumption of dairy products and vegetable oils. In China, higher projected caloric intake is linked to higher per capita meat consumption following abatement of the African Swine Fever (ASF) outbreak (Frezal, Gay and Nenert, 2021[22]).

Figure 3. Change in per capita calorie and protein intake in the baseline



Source: OECD based on the *OECD-FAO Agricultural Outlook 2020-2029* (OECD/FAO, 2020[13]).

In the Oceania region, caloric intake is expected to slightly increase over the coming decade (1%). However, some changes in dietary composition are expected. Poultry and vegetable oils are projected to increase their share of the diet while consumption of cereals, sugar, dairy and red meats is projected to decline. As a result, protein intake will be slightly declining (-2%) (Figure 4).

In Asia as a whole, robust income growth is expected. As a result, demand for calorie and nutrient-dense foods is expected to rise. Continued urbanisation and income growth in the region is projected to increase average caloric intake by 5%, mainly due to increased consumption of vegetable oils and animal products, particularly dairy products, the only food groups to increase its calorie share over the outlook period. Average protein intake is also expected rise by 4%, mainly due to increased consumption of fresh dairy products (Figure 3).

Food consumption per capita in North America is the highest of all regions, encouraged by the higher per capita incomes and urbanisation rate which affect both the level and composition of food intake. Nevertheless, per capita caloric intake is projected to slightly decline over the coming decade (-1%) while the average protein intake will remain stable (Figure 3) largely driven by a decline in per capita sugar consumption, due to increasing concerns about the negative health effects of excessive sugar overconsumption, and in per capita wheat consumption (a staple food) which is slowly declining has incomes rise (Figure 4).

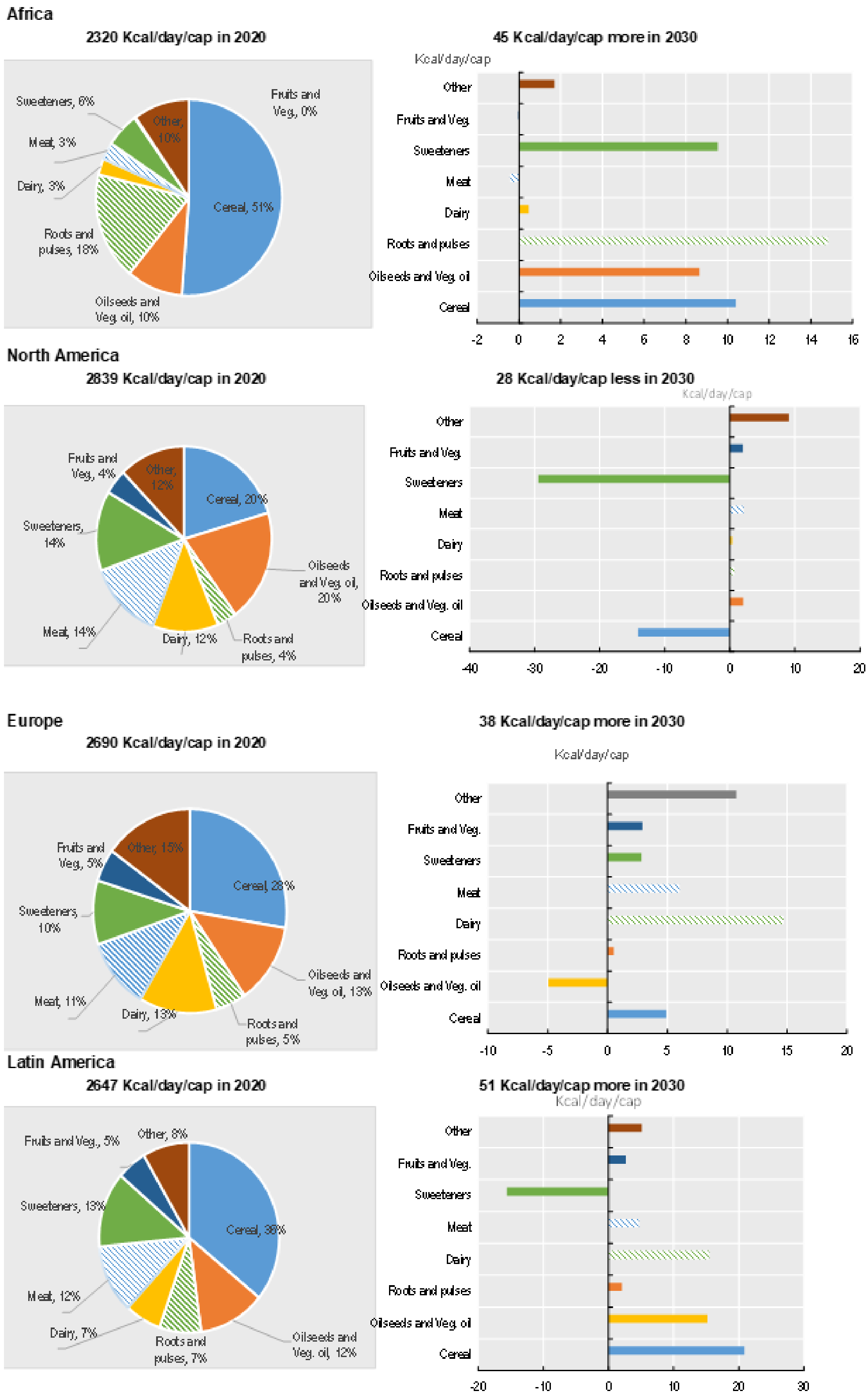
In Latin America, per capita caloric consumption is projected to rise (2%), with increases coming from vegetal products, including cereals and vegetable oils (Figure 4). Protein intake in the region is also expected to increase due to higher consumption of dairy products (Figure 3). Calorie intake of sugar will decline following a longer-term decline in the region's sugar consumption through initiatives to address the rising prevalence of overnourishment.

Although Africa has experienced economic growth in recent years, prevailing levels of income inequality will prevent these growth rates from translating into significant improvements in the disposable income of large parts of the population. This will hamper growth in food consumption, particularly of more expensive foods like meat products. Per capita caloric intake is expected to grow by 2%, mostly driven by an increase in consumption of rice, roots and tubers, vegetable oils and sugar (Figure 4). Per capita protein intake in the region is expected to remain stable at the current low levels (Figure 3).

In Europe and Central Asia, daily per capita caloric intake is projected to increase by 1%, mainly due to increased consumption of dairy and meat products (Figure 4). Food demand for vegetable oils is expected to fall marginally in Europe over the next decade, reducing its contribution to regional diets. At the same time food demand for sweeteners is projected to decline in spite of an increase demand for HFCS in caloric sugary soft drinks. Per capita protein consumption in the region is projected to increase by 3%, mostly driven by increased cheese and poultry consumption (Figure 3).

In the baseline, a decline in real international reference prices for several agricultural commodities is expected. However, three factors are expected to lead to overall increases in food expenditure at the global level (Figure 5). First, consumer prices reflect not only the price of the underlying primary agricultural product but also the costs of processing, transport and distribution, among other factors. Historically, these costs have created a growing wedge between consumer prices and agricultural commodity prices, and this trend is expected to continue over the coming decade. Second, as incomes grow, consumers shift their food consumption to higher-priced items. The combined effect of these factors explains why, despite a decline in real terms in agricultural commodity prices, the food expenditure index is expected to increase by 18% in real terms over the coming decade.

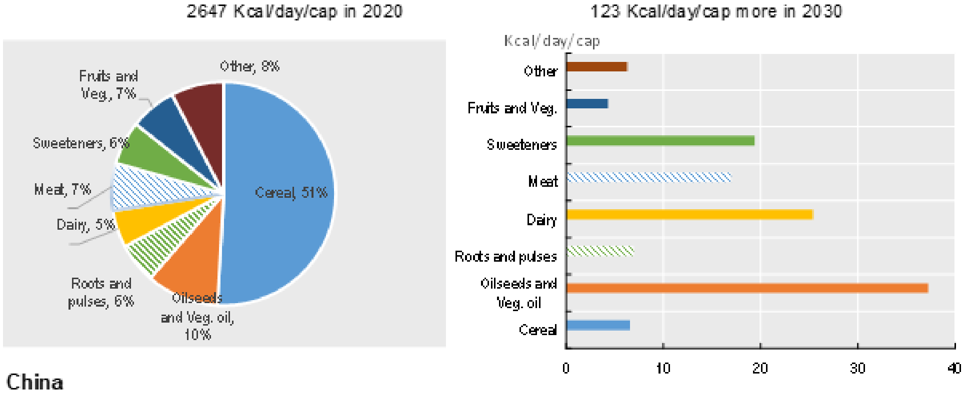
Figure 4. Regional source of caloric intake (2020), net caloric change between 2030 and 2020



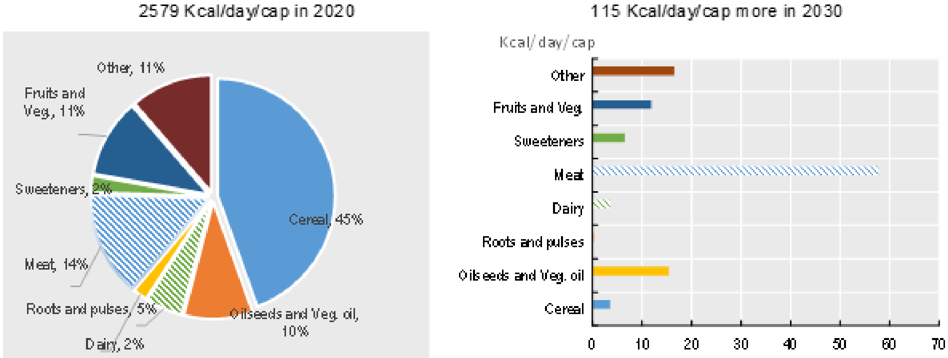
Notes: Staples represents cereals, oilseeds, pulses, roots and tubers.
Source: OECD analysis using the Aglink-Cosimo model.

Figure 4. Source of caloric intake (2020), Net caloric change between 2030 and 2020 (*cont.*)

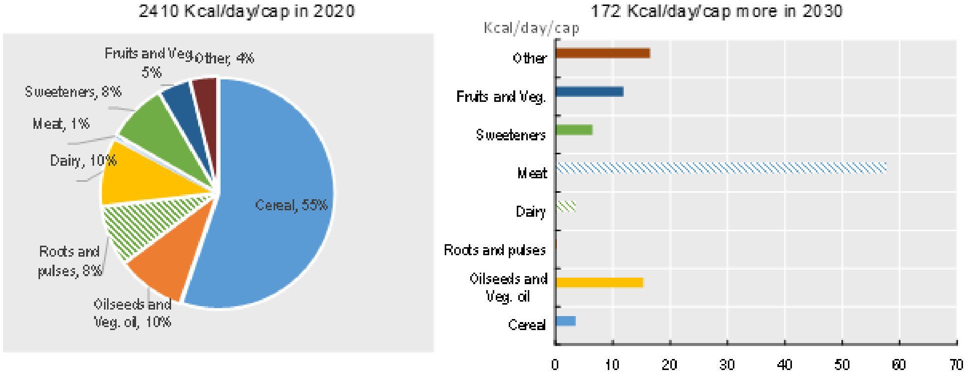
Asia



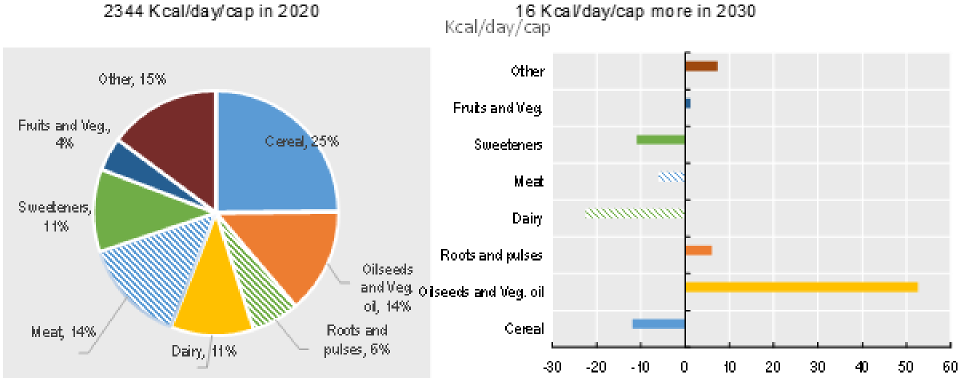
China



India

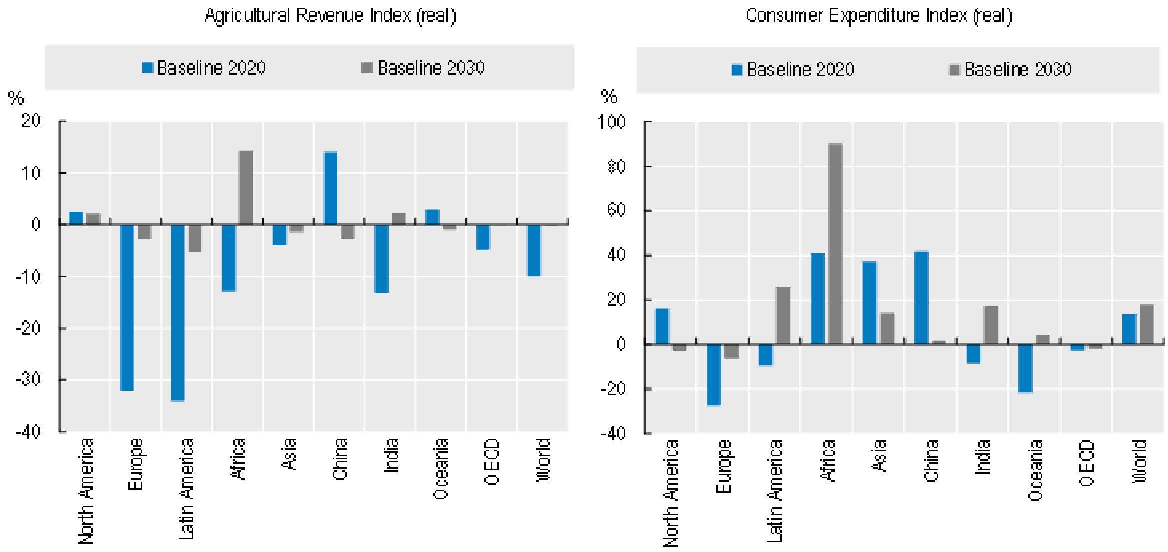


Oceania



Note: Staple food consist of cereals, oilseeds, pulses, roots and tubers.
Source: OECD analysis using the Aglink-Cosimo model.

Figure 5. Change in agricultural revenues and consumer expenditures in the baseline



Note: Real values are obtained by dividing the Index by the US GDP deflator (2010=1).
Source: OECD based on the *OECD-FAO Agricultural Outlook 2020-2029*.

As with all existing indicators in the model, the projected evolution of the prevalence of undernourishment and overnourishment indicators should be viewed as a reference point only against which different scenarios can be compared. The path of the prevalence indicators under the baseline projection is essentially trend-based and is not driven by the variation in caloric intake, although changes in these indicators under the various scenarios are responding to one of the factors contributing to weight change, i.e. the variation in food energy availability.[12]

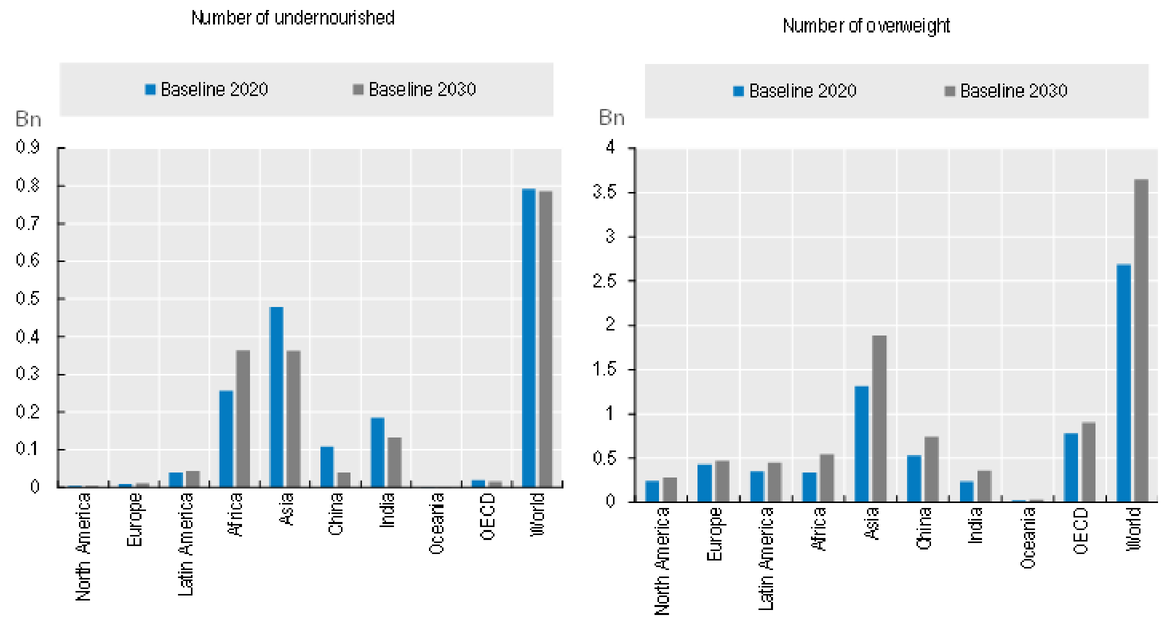
In 2020, 791 million people worldwide were undernourished,[13] with most of this population located in Asia (381 million) and Africa (250 million). The trend-based projections in the baseline imply that undernourishment will reach around 787 million people in 2030.

In 2020, 2.7 billion people in the countries covered were overweight (BMI greater than or equal to 25), while 954 million were obese (BMI greater than or equal to 30). The trend-based projections in the baseline imply an increase of 36% by 2030, representing 3.7 billion overweight (Figure 6) and 1.4 billion obese. Relative to the global population, this corresponds to an increase in the prevalence of overweight from 35% to 43% and in the prevalence of obesity from 12% to 17%.

[12] See Annex A for further details.

[13] The trend base undernourished estimates using the October 2019 FAO Food Security Indicators (FSI) differs from the latest available FAO numbers. Whenever the Prevalence of Undernourishment from the FSI is indicating <2.5% this report assume that it is equal to 1%.

Figure 6. Evolution in the number of undernourished and overweight in the baseline



Source: OECD based on the *OECD-FAO Agricultural Outlook 2020-2029*.

Livelihoods

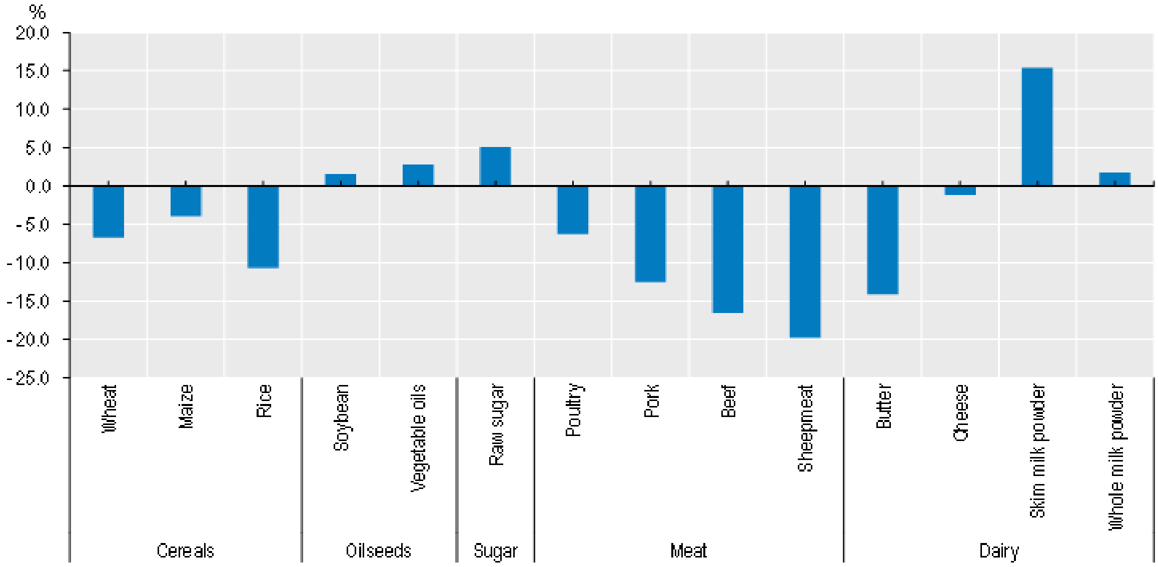
A full accounting for livelihoods would examine net incomes and also cover other segments of the food chain, e.g. the impact on food manufacturers, in addition to the agricultural sector. However, the detailed data necessary to construct such indicators are currently not available in an internationally comparable format. Instead, the indicator of livelihoods used here captures only the effects on agricultural producers (farmers or ranchers) and looks only at gross revenues (i.e. the sum of sales revenue and subsidies). Agricultural gross revenues are an important driver of net incomes for agricultural producers, and the indicator thus sheds some light on trends affecting livelihoods for this population.

As shown in Figure 7, over the coming decade real prices[14] are expected to fall for cereals (wheat: -7%, maize: -4% and rice: -11%) and meat (poultry: -6%, pork: -13% and beef: -17%). Real prices are expected to remain relatively flat for soybeans (+2%) and vegetable oils (+3%) and to increase for sugar (+5%). Whole milk powder (a proxy for milk prices) is also expected to see a relatively flat price trend (+2%), although prices for specific dairy products show more variation.

While real prices are projected to generally decline in the baseline, agricultural production for most commodities covered in the model is expected to continue to grow at the global level. For instance, maize production is set to expand by 15%, rice, and wheat by 11%. Poultry production is expected to increase by 13%, beef by 8%, pork by 14% and milk by 17%. This expected growth in output will offset the fall in real prices.

[14] Nominal prices adjusted for inflation.

Figure 7. Real price change of agricultural commodities in the baseline



Note: Real price change expressed as the change between the 2018-2020 average and the average under the baseline.
Source: OECD based on the *OECD-FAO Agricultural Outlook 2020-2029*.

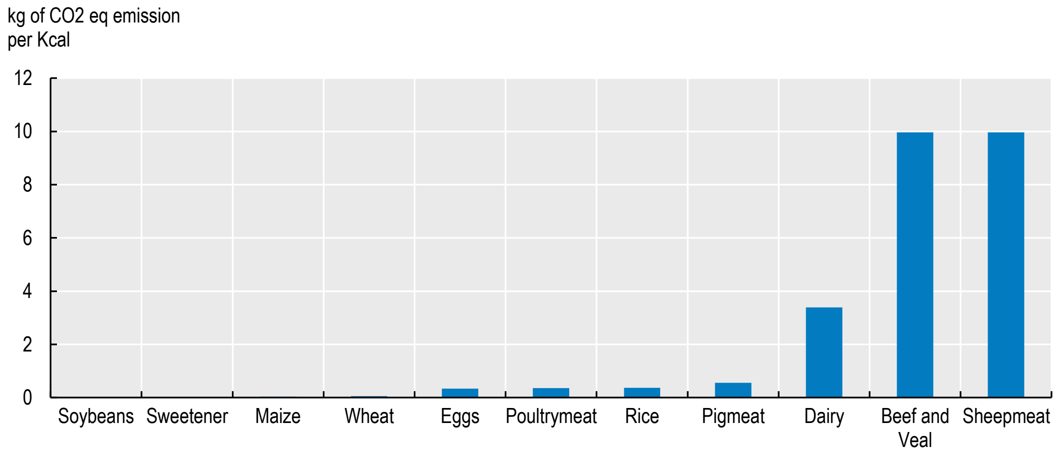
However, despite output growth outpacing real price declines, the index of real global agricultural revenues used in this report shows a decline of 4% over the projection period. This decline can be explained partially by changes in real exchange rates. The index of real global agricultural revenues effectively sums real agricultural revenues in each country and uses the real exchange rate to convert these into real USD terms. All else being equal, a real depreciation of a country's currency relative to the USD would translate into a reduction in agricultural revenues. The exchange rate assumptions in the baseline imply real depreciations for Australia, Brazil, China, the Euro zone, Ukraine, and South Africa (with most other real exchange rates assumed to be stable). As these countries are all major agricultural producers, real exchange rate assumptions tend to lower the index of real global agricultural revenues as measured here. Since exchange rate assumptions are kept constant across all scenarios, however, the performance of the index relative to the baseline can still indicate how global agricultural revenues are affected.

Environmental sustainability

For the purposes of this report, the GHG emission measure is limited to direct emissions from agriculture. These emissions account for about 12% of global anthropogenic GHG emissions (IPCC, 2019[3]). About 70% of global direct GHG emissions from agriculture are related to livestock, particularly ruminants such as cattle, which emit GHG through enteric fermentation and manure (OECD, 2019[23]). The GHG impacts of agriculture and food systems are complex, and understanding how changes in global dietary compositions can affect GHG emissions can help both consumers and producers assess how various consumption decisions may impact the climate. Other important sources of direct GHG emissions include the application of synthetic fertilisers to agricultural soils (responsible for 13% of direct emissions from agriculture) and anaerobic decomposition of organic matters on paddy rice fields (10%) (OECD, 2021[5]).

This report does not consider individual GHGs but looks at the aggregate of all direct emissions from agriculture, expressed in GHG million tonnes CO_2-equivalent ($MtCO_2$-eq). The carbon intensity of food is represented by country-specific emission factors expressed in $kgCO_2$-equivalent per unit of kilocalories content. The GHG emission factors used by the model based on FAO estimates are highly dependent on the type and quantity of the commodity used for food consumption (Figure 8). This report does not take into account that imported food may have a different carbon footprint than domestically-produced food.

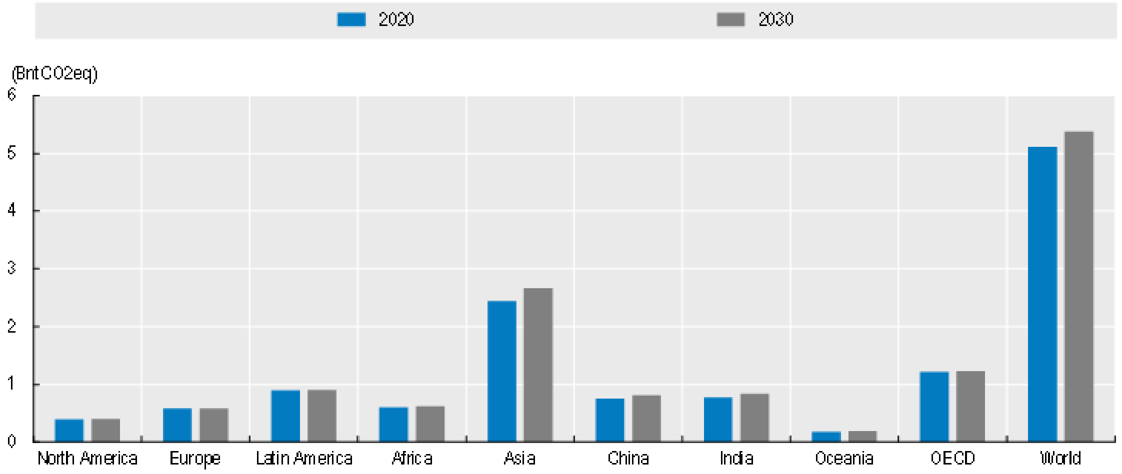
Figure 8. Intensity of emission by commodity, global average, 2020



Source: Aglink Cosimo model.

Over the past decade, direct emissions from agriculture increased by 5%. Over the projection period, and assuming no changes in current policies and technologies (and therefore emission intensity coefficients), direct GHG emissions are expected to grow by 5%. This represents an increase of 267 $MtCO_2$-eq from the base period. Although direct GHG emissions from agriculture vary by region, livestock-related emissions form the main contributor (80%) of this global increase. Most of the increase in direct emissions is projected to occur in emerging and low-income regions due to higher output growth in production systems that are more emission-intensive (Figure 9). This increase will be driven mainly by a faster rate of expansion in cattle herds than seen in the previous decade.

Figure 9. Total direct greenhouse gases emissions from agriculture



Source: OECD based on the *OECD-FAO Agricultural Outlook 2020-2029.*

In addition to direct GHG emissions from agriculture, land use changes generate GHG emissions and are also associated with other environmental problems, such as declining biodiversity and increasing soil erosion (Hardelin and Lankoski, 2018[24]) (OECD, 2019[25]). Cropland, which accounts for 31% of total agricultural land use in the base period, is expected to remain stable in the next ten years, in contrast with the 2% growth seen over the past decade. Pasture, which makes up the most of total agricultural land use, is expected to fall by 0.3%, in contrast to the 1.4% decline seen in the past decade. Other non-agriculture land use[15] will increase by 1.1%, mostly due to increasing urbanisation. Overall, global agricultural land use changes are influenced by anthropogenic activities[16] and is projected to fall by 0.2% in the baseline (Table 3).

Table 3. Change in agricultural land use, baseline (million hectares)

	2020 est.	2030 proj.	% Variation
World agricultural land use	4 740	4 730	-0.2
World cropland land use	1 488	1 489	0.0
World pasture / forage land use	3 252	3 241	-0.3
World other non-agricultural land use	4 197	4 242	+1.1
World forest area	3 965	3 930	-0.9

Source: OECD analysis using the Aglink-Cosimo model.

3. Scenario description

A significant share of the world's population consumes sugar and fat in quantities that exceed WHO recommendations. The WHO recommends that an individual’s consumption of free sugar should not represent more than 10% of calorie intake of a balanced diet, and that fat should not represent more than 30% (World Health Organization, 2015[11]; World Health Organization, 2018[12]). This report quantitatively assesses the potential impact of dietary changes on food security and nutrition, livelihoods and climate change. The stylised[17] scenarios analysed provide some understanding of the changes in each of these dimensions as a result of illustrative shifts in diet and the synergies and trade-offs that arise. By doing so, they indicate that dietary changes could positively contribute to achieving the UN SDGs, Goal 2 in particular.

To illustrate the potential synergies and trade-offs from dietary changes, each scenario gradually introduces exogenous reductions in sugar and fat demand in the countries and regions covered in the model. The scenarios are structured to bring average diets closer in line with WHO recommendations for sugar and fat intake, without affecting the dietary intake of undernourished populations. The choice of dietary recommendations used for the scenarios is based on the model commodity and nutrients coverage. As is the case in several diet-related studies which try to measure the impact of dietary changes, the reduction in sweeteners and fat consumption are exogenously implemented. In doing so, consumer behaviour is assumed to change without external intervention and that no costs are incurred in bringing about this change (Geibel, Freund and Banse, 2021[26]). Several policies may lead to reductions in sugar

[15] Other non-agricultural land use includes areas not suitable for agriculture, cities, or areas used for transport.

[16] The land use variation in the Aglink-Cosimo model is influenced by population growth, urban expansion, increasing demands for energy and food, changes in diets and lifestyles, education, and income.

[17] In reality, the magnitude of the changes in the consumption of the targeted commodities seems to go beyond that which is likely in the time frame which is why the term “stylized” is used to describe the type of scenarios in this report.

and/or fat consumption (Box 2). Although no so such policies where explicitly introduced to induce food demand changes in the stylized scenarios, such policy mechanisms would likely have a cost and impact the results obtained. Nevertheless, a mix of policies – as opposed to any single policy – would be needed to encourage dietary changes. In the real world, the results would see smaller changes in demand than those assumed to be the case in the stylized scenarios presented in this paper.

Box 2. Policies to encourage healthier food choices

Public intervention in the area of food and health

Policy solutions to reduce unhealthy food consumption patterns mostly focus either on the consumer or on the actions of processors and retailers. A four-track approach would help to encourage healthier food choices in a way that is consistent with wider objectives for the food and agriculture sector including objectives related to environmental sustainability and to the livelihoods of agents along the food chain.

The first track would be to tackle unhealthy food choices via demand side public interventions such as the provision of public information and counselling. Such instruments do not induce other distortions into the functioning of the food system. The evidence base suggests that such policies work and are cost-effective, but are unlikely to be sufficient. A particular need is to target groups with poorer diets.

A second supporting track is to work with industry at the supply-demand interface, e.g. in product reformulation or in introducing and testing labelling schemes. There is an emerging evidence base that such policies can be effective, but that specific design features are critical for their success. Simplified labelling schemes offer considerable potential, with a need for international cooperation given the global nature of the food industry. A potential avenue for public-private collaboration is through behavioural nudges. The scope for testing the effectiveness of such approaches is enhanced by digital technologies and associated possibilities to collect information on consumers' food acquisition and intake as well as on the food environment more generally. However, private incentives are likely not to fully align with public ones.

Hence, as a third track, some firmer regulations may be needed to modify processors' and retailers' behaviour. Examples of such measures could include rules on promotion, advertising confectionery to children, and on unhealthy product compositions, especially those which target babies and children.

A fourth track is fiscal measures, including consumption taxes on products that are "unhealthy" when consumed excessively.[1] Such policies may have some effect, but are prone to slippage (e.g. with consumers sourcing from other markets) and may be regressive in terms of their higher impact and incidence on those with lower incomes.

Across these four different policy approaches, further research will be needed to determine which combinations of instruments are likely to be most effective.

1. For example, a systematic review of real-world sugar-sweetened beverage (SSB) tax evaluations, which examine the overall impact on beverage purchases and dietary intake by meta-analysis, found that a 10% tax on sugar-sweetened beverages led to an average 10% decline in dietary intake (Teng et al., 2019[27]).
Source: Extracted from Giner and Brooks (2019[28]).

Scenario definitions and implementation of the WHO guidelines

The WHO guidelines define their recommendations for free sugar and fat intake as a share of an appropriate total caloric intake. The WHO guidelines do not provide precise numerical targets for what constitutes an appropriate total caloric intake, but suggest that caloric intake should be in balance with energy expenditure, which differs by person depending on gender, age and level of physical activity, among other factors. To translate WHO recommendations into specific values, the dietary change scenarios in this report rely on the Average Daily Energy Requirement (ADER) available from FAO for a wide range of countries. The ADER captures the average calorie intake requirements of an average individual, taking into account a range of factors such as demographics and levels of physical activity (Table 4).

Compliance with WHO guidelines involves bringing the actual intake of sugar or fat in Kcal/day/cap to the level indicated as a percentage of the ADER in Kcal/day/cap for each country and region. However, WHO guidelines specifically state that the recommendations do not apply to individuals with malnutrition. The approach taken here is therefore to model calorie reduction across the whole population, but excluding undernourished individuals or individuals who would develop undernourishment as a result of the guidelines.

Table 4. Average Daily Energy Requirement (ADER), (Kcal/day/cap)

	Average 2018-20 est.	Average 2028-30 proj.
North America	2544	2537
Europe	2519	2515
Latin America	2388	2402
Africa	2216	2252
Asia	2358	2370
China	2442	2441
India	2314	2336
Oceania	2415	2421
OECD	2454	2457

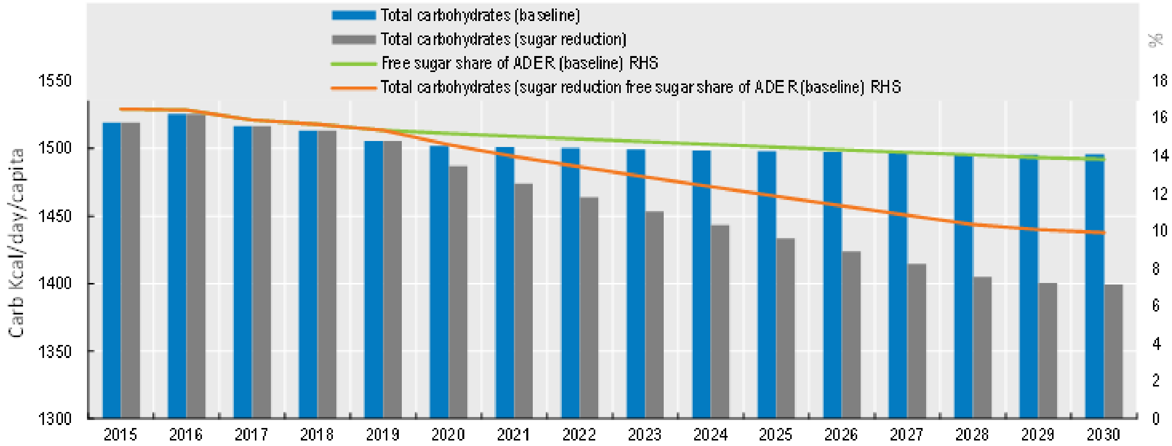
Source: FAO (2001).

The resulting changes in consumption patterns imposed by the scenarios were phased in over a ten-year period to allow markets to adjust. For example, if a country's free sugar intake is above 10% of the ADER, the quantities of sweeteners consumed are exogenously reduced in ten equal instalments[18] until they represent only 10% of the ADER.[19] Figure 10 illustrates this mechanism with Argentina used as an example. Consumption of food products not targeted by the scenario remains endogenous. Countries' caloric intakes of those products continue to fluctuate and adjust to market changes, impacting the overall supply of calories coming from untargeted food products. In view of the fact that food consumption is spread over a ten-year period so as to represent a more realistic transition period for dietary changes to occur, the effects of the model shock are not complete by 2030, and it could be expected that prices will recover in subsequent years. Price cycles depend on the length of the shock, which in turn is influenced by both the degree of time-dependency in the model equations and the extent to which that time-dependency influences the market.

[18] Equivalent to the respective food share, in Kcal of free sugar or fat in 2020, for each commodity targeted by the scenario.

[19] Until the model final iterations are within +/- 0. 5% of the dietary goal.

Figure 10. Sugar reductions over a ten-year period: Argentina



Note: Sweeteners mostly make up carbohydrates.
Source: OECD analysis using the Aglink-Cosimo model.

To evaluate the implications of a dietary shift towards the WHO guidelines, three stylized scenarios are defined.

The first scenario assesses the impact of reducing consumption of free sugars to a maximum of 10% of an appropriate caloric intake, in line with WHO recommendations. In practical terms, this scenario affects consumption of sugar and HFCS. In countries where calories from sugar and HFCS account for more than 10% of ADER (Annex D), the scenario implements a gradual reduction in equal proportion on food consumption to bring this share down to a level equivalent to 10% of ADER. The reduction in food quantities is proportional to year 2020 of the carbohydrates caloric food share of the targeted commodities.[20] The countries affected by this scenario represent 37% of the world population.

The second scenario assesses the effects of bringing diets in line with the WHO recommendation that fat should not exceed 30% of an appropriate caloric intake. In countries for which consumption of fat is higher than 30% of the ADER (Annex D), a reduction proportional to each food product's caloric share of fat is imposed on the consumption of butter, vegetable oil, beef and veal, poultry meat, pigmeat, sheepmeat, eggs, fresh dairy products, and cheese. These products were chosen because they have a relatively high fat content, typically consumed in large quantities, and are modelled as single commodities. The scenarios do not consider shifting consumption patterns towards alternative sources of proteins, such as using different plant-based proteins, cultured meat and biotechnological innovations. The chosen commodities are also in line with the WHO recommendation to consume moderate amounts of milk, dairy products, and vegetable oils, as well as to limit meat, and particularly red meat consumption. These dietary recommendations lower both NCDs and the environmental impact (WHO, 2018[29]). The countries affected by this scenario represent 48% of the world population.

[20] For example, sweeteners reduction: if $ADER_{(2029)}$ = 2200 Kcal, and Free $sugar_{(2020)}$ 300 Kcal = $Sugar_{(2020)}$ 200 Kcal + $HFCS_{(2020)}$ 100 Kcal. Free $sugar_{(2029)}$ = 2/3 $Sugar_{(2029)}$ 132 Kcal + 1/3 $HFCS_{(2029)}$ 88 Kcal = 10% $ADER_{(2029)}$ = 220 Kcal.

The third scenario is a combination of the sugar and fat reduction scenarios.

The reduced calorie intake and associated spending on the targeted commodities resulting from each dietary change are performed without imposing isocaloric compensation with other agricultural commodities.[21] This increases the magnitude of the impact on all indicators. The rebound effect, i.e. a shift in food expenditure towards other resource-intensive goods, would offset to a certain extent, for example, the reduction in GHG emissions (Geibel, Freund and Banse, 2021[26]).

4. Results

Scenario 1: Sugar reduction

Under the sugar reduction scenario, global per capita caloric intake from sugar falls by 8% and intake of calories from HFCS falls by 19% (with a proportionally smaller market share) in 2030 relative to the baseline value for 2030. These combined decreases result in an overall decline in carbohydrate intake of 1.2%. Global sugar production in this scenario is 8% lower relative to the baseline, while sugar prices (as measured by the sugar price) decline by 18% in real terms.

The scenario's impact on other commodities is relatively minor. Despite reduced demand for maize due to lower consumption of HFCS, maize output falls by only 0.2% and prices by 1%. The lower demand for sugar and HFCS frees up land for other crops, such as soybeans and other coarse grains in the Americas, Europe and Oceania. In the non-sugar-producing regions, the scenario results lead to slightly lower production and prices for several crops and, through effects in feed markets, for animal products.

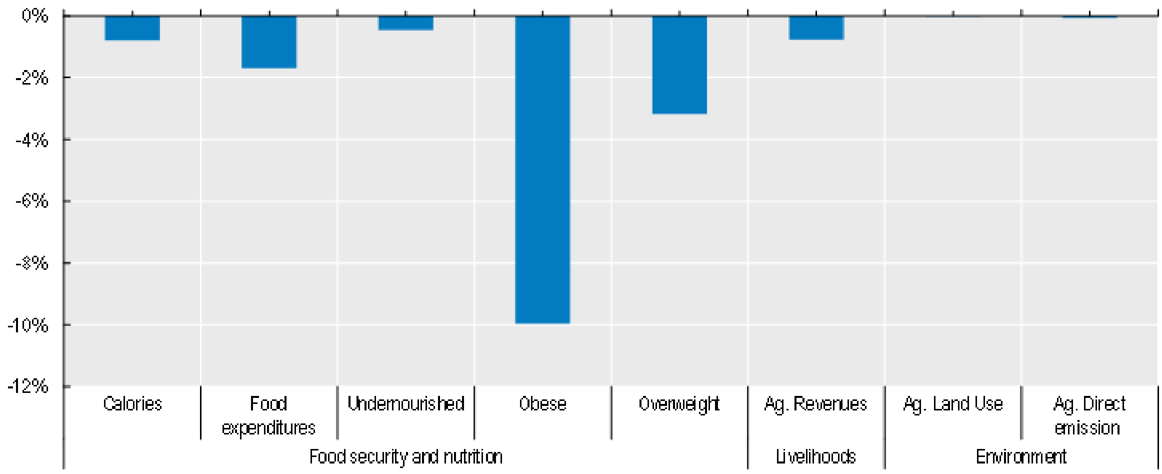
Under this scenario, per capita caloric intake at the global level falls by 0.8%. Despite this relatively small effect, the reduction in sugar consumed affects overall caloric intake, mainly in higher income countries. Under this scenario, the prevalence of obesity declines globally by 10% (139 million persons) and overweight declines by 3% (116 million persons), with OECD countries accounting for 60% of this reduction.

As market impacts are mostly confined to sugar markets, the effects of this scenario on food expenditure and agricultural revenues are limited (-2% and -1%, respectively). Other effects, including on global land use (-0.1%) and direct GHG emissions from agriculture, are minor.

[21] The Aglink Cosimo partial equilibrium does not include mechanisms that divert to other economic sectors the spending that is caused by changes in dietary patterns. Furthermore, the analysis does not include compensation effect of replacing elements of a diet with others, aside from a small income effect coming from the model elasticities. The scenarios show that populations that are above the fat or sugar threshold buy less unhealthy food, which results in less food overall. Consumers – at least those with any money – do not have food calorie targets.

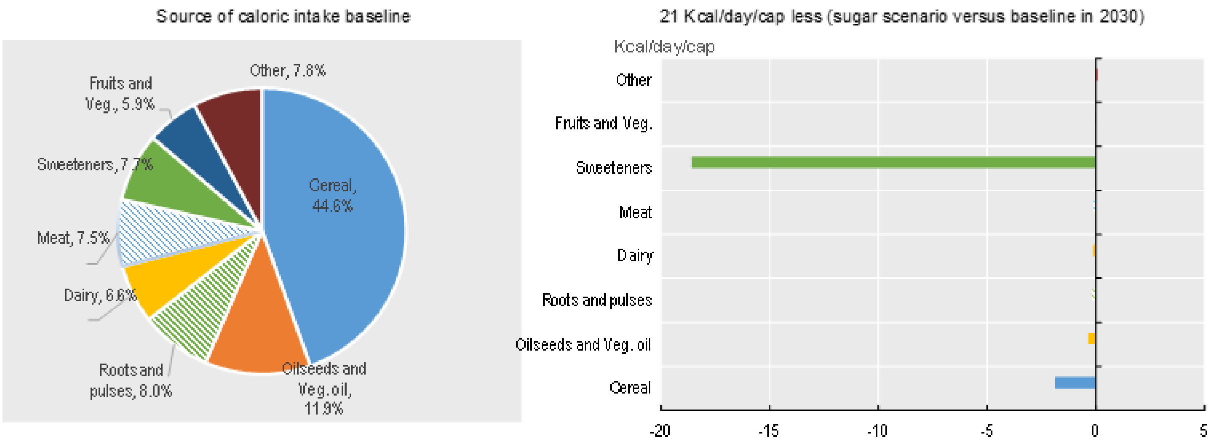
Figure 11. Global change in indicators of the triple challenge: Sugar scenario

Scenario changes relative to the baseline (%)



Source: OECD analysis using the Aglink-Cosimo model.

Figure 12. Source of caloric intake in the baseline (2030), Net caloric change between sugar scenario and baseline in 2030



Notes: Staples represents cereals, oilseeds, pulses, roots and tubers.
Source: OECD analysis using the Aglink-Cosimo model.

Scenario 2: Fat reduction

Effects of the fat reduction scenario are more pronounced. At the global level, caloric intake from fat declines by 11% relative to the baseline, resulting in a reduction in overall global caloric intake of 3.8%. As animal products are important sources of both fat and protein, this scenario also leads to an important reduction in global protein intake, which falls by 5% relative to the baseline.

This scenario has important implications for world markets. Global production of animal products falls significantly, with reductions in poultry (-17%), beef (-18%) and pork (-19%) production. Among dairy products, milk production declines by 6% and cheese production falls by 32%. In addition, global butter and vegetable oils production declines, by 7% and 6 % respectively.

Under the fat reduction scenario, commodity prices also decline by 2030. Real prices fall strongly for beef (-63%), pork (-62%), poultry (-43%), vegetable oils (-33%), cheese (-53%) and butter (-72%). Sugar prices decline by 12%.

In turn, the reduction in demand for animal products reduces demand for animal feed. This leads to lower production of maize (-8%) and soybeans (-9%), with correspondingly large price effects (-45% for maize and -40% for soybeans). The net result is a decline in global agricultural revenues of 29% relative to the baseline.

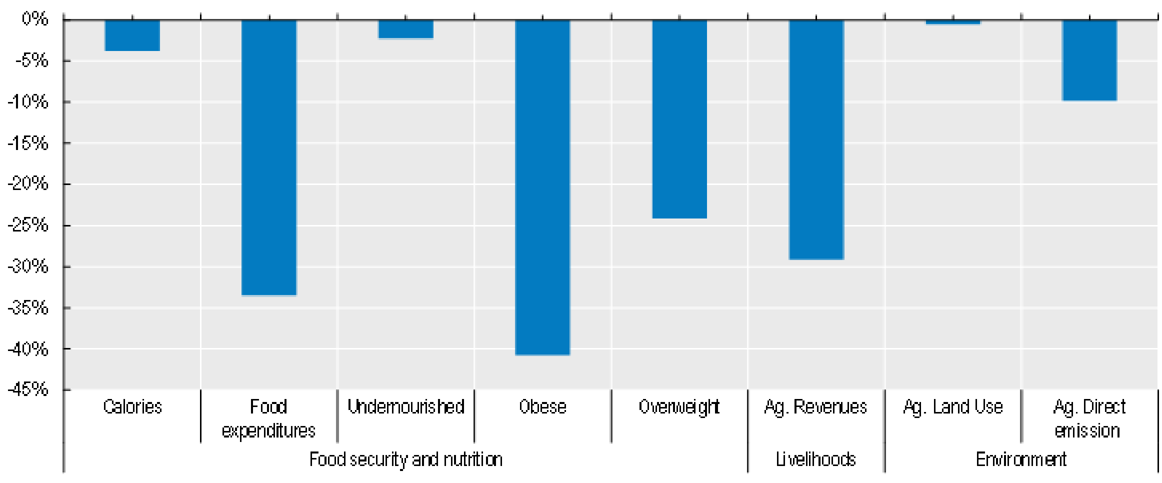
Despite declines in caloric intake from fat, global trade in products with a high fat content increases under this scenario. In countries and regions where consumption of these products is high, production and exports are often also high. As domestic consumption falls in these exporting countries, domestic producers find other buyers on international markets, often by reducing their prices. Other regions with lower per capita fat consumption consequently expand their caloric intake from fat due to these lower import prices. Thus, while global caloric and protein intake falls under this scenario, there is a modest regional increase in some areas (e.g. India and Africa). Global trade flows increase for meat (poultry +28%, pork +67% and beef +35%) and some dairy products (cheese +83% and butter +125%).

In spite of this convergence effect, however, the overall global reduction in caloric intake results in a global decline in obesity of 41% (571 million people) and in overweight by 24% (882 million people). As prices decline for most commodities, global food expenditure decreases by 33%, resulting in a 2% a decline in undernourishment (18 million people) at the global level.

The significant reduction in agricultural production under Scenario 2 leads to lower direct GHG emissions (-10%) compared to the baseline. The net effect is a reduction in direct emissions of 5% over the course of the decade, compared to an expected increase by 5% under the baseline. Relative to the baseline, the fat reduction scenario reduces direct emissions by about -530 $MtCO_2$-eq. The impact on global land use in this scenario remains small (-0.5%); the dominant effect is to lower cropland use to the benefit of pasture land, as ruminant production remains more profitable than crop production, and forest area which benefits from the overall lower agricultural profitability.

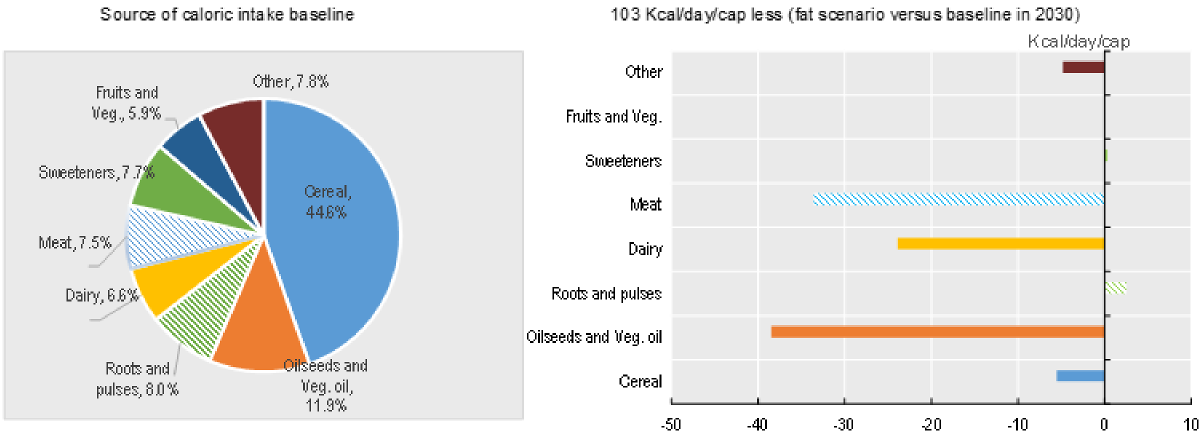
Figure 13. Global change in indicators of the triple challenge: Fat scenario

Scenario changes relative to the baseline (%)



Source: OECD analysis using the Aglink-Cosimo model.

Figure 14. Source of caloric intake in the baseline (2030), Net caloric change between fat scenario and baseline in 2030



Notes: Staples represents cereals, oilseeds, pulses, roots and tubers.
Source: OECD analysis using the Aglink-Cosimo model.

Scenario 3: Sugar and fat reduction

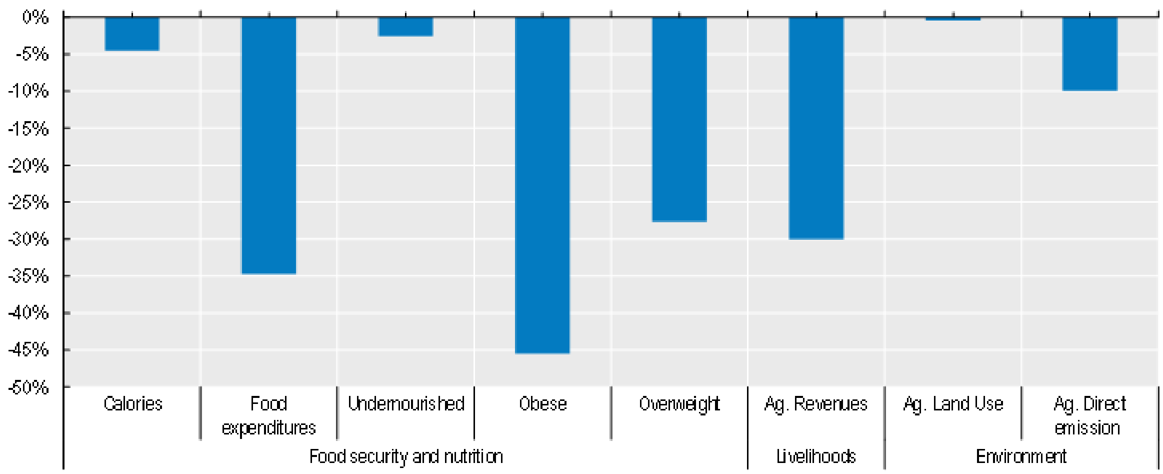
The third scenario models a combination of a reduction in sugar and fat intake. The caloric intake outcome is essentially the sum of the results of the two previous scenarios. Under this third scenario, global per capita calories consumed from sugar falls by 8%, calories from HFCS fall by 16%, and calories from fat fall by 11%.

Together, the reduction in sugar and fat consumption results in a 4.6% decline in global caloric intake, a 5.1% decline in protein intake, and a 1.7% decline in carbohydrate intake. Across the world, this combined scenario reduces obesity and overweight by 46% (638 million people) and 28% (1 billion people), respectively, from the baseline value. By contrast, Africa and India benefit from lower prices under this scenario and expand their caloric and protein intake, leading to an increase in overweight in those regions of 1% and 5%, and in obesity of 0% and 9% respectively. Undernourishment declines in both regions by 3% and 5%, respectively (18 million people).

The market impact of this third scenario also sums the impacts of the first and second scenarios. Real sugar prices fall by 28%, and strong price declines are found for poultry (-44%), pork (-62%), beef (-63%), butter (-73%), and cheese (-53%). As a result, the food expenditure index shows a steep decline of 35% and agricultural revenues fall by 30% relative to the baseline. As expected in this combined scenario, direct GHG emissions decline slightly more than in Scenarios 1 and 2, by nearly 10% (-532 $MtCO_2$-eq). The impact on global land use remains small (-0.5%).

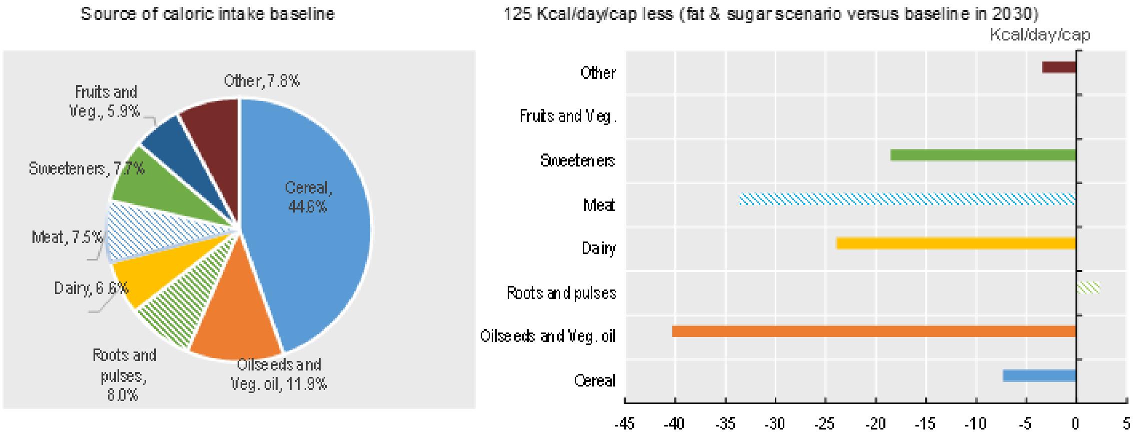
Figure 15. Global change in indicators of the triple challenge: Sugar and fat scenario

Scenario changes relative to the baseline (%)



Source: OECD analysis using the Aglink-Cosimo model.

Figure 16. Source of caloric intake in the baseline (2030), Net caloric change between Sugar and Fat scenarios and baseline in 2030



Notes: Staples represents cereals, oilseeds, pulses, roots and tubers.
Source: OECD analysis using the Aglink-Cosimo model.

While the scenarios explored are stylised and based on the assumptions of the underlying modelling framework, the results highlight the existence of synergies and trade-offs from large-scale dietary changes. For example, the scenario results show an increase in caloric and protein intake in some of the poorest regions of the world (i.e. Africa and India), which benefit from the lower food prices seen in the scenarios and consequently increase their consumption.[22] In these regions, higher caloric intake decreases undernourishment but increases the prevalence of overnourishment. Overall, however, the scenarios show increased trade from countries with caloric surpluses to those with caloric deficits, benefiting nutritional intake in the poorest regions of the world.

[22] A general equilibrium model would include income effects of lower agricultural commodities which may be important in poorer regions where agriculture is an important share of economic activity.

5. Conclusion

While the model, the selected indicators, and the methodology suffer from several limitations – as highlighted respectively in Box 1 and Section 2 and Annex A – the three stylised scenarios explored in this report highlight the key trends of each of the dimensions of the triple challenge facing global agriculture and food systems; food security and nutrition, livelihoods, and climate change. Results from the model indicate that the stylized dietary changes are likely to have a significant impact on farmers' livelihoods, while reducing both greenhouse gas emissions and the prevalence of over and undernourishment. The consumption of key macro nutrients within the Acceptable Macronutrient Distribution Range (AMDR)[23] would be maintained. The degree of impact, however, varies (Annexes B and C).[24]

The decrease in fat consumption implied by WHO recommendations, which affects vegetable oils and livestock product consumption in particular, has a much stronger impact on all indicators of the triple challenge used in this analysis than does the reduction in sugar consumption. This is primarily due to the size of the vegetable oils and livestock sectors relative to other sectors globally and within diets. In addition, in the baseline trajectory, current sugar consumption levels are closer to WHO recommendations than are fat consumption levels. This means that the adjustment factors applied are relatively smaller for the sugar scenario than for the fat scenario.

The three scenarios affect the dimensions of the triple challenge to different degrees and in different directions. The scenarios involving fat reduction have a stronger beneficial environmental effect in terms of GHG emissions than does the reduction in sugar. Total direct agricultural GHG emissions are lower under these scenarios since some products with a relatively high fat content, like beef and dairy, are also carbon-intensive.[25] Whilst changes in land use are small, they contribute to reducing the land used by the agricultural sector. Food security and nutrition benefit from a diet which reduces the consumption of sugar and fat. The reduction in food prices from the dietary changes induces a decrease in undernourishment while lowering sugar and fat intake reduces overnourishment (synergies). Under all the scenarios, food prices and global production declines, negatively impacting the livelihood dimension (trade-offs).

The impacts of the dietary changes differ widely across regions and countries. The necessary nutritional adjustments required by each region and country to meet the WHO recommendations depends on baseline consumption patterns. There are also heterogeneous impacts, with different trends in net importing (lower food expenditure) and net exporting countries (lower agricultural revenues) whilst the GHG emissions changes are influenced by the basket of food consumed in specific regions and countries (GHG intensity) (Kim et al., 2020[30]). A detailed investigation[26] of the effects by country and commodity using more granular approach might expose higher localised adjustment costs that could require specific action. Using more comprehensive measures of the triple challenge might uncover synergies and trade-offs that are hidden from view in this aggregated approach, such as those related to the income effect on livelihoods where

[23] AMDR for protein is 10%–35%; for carbohydrates it is 45%–65%; and for fat it is 20%–35% (Panel on Macronutrients et al., 2005[45]).

[24] To simplify the graphical exposition, Annexes B and C show only regional aggregates (except for China and India), including a subset of indicators.

[25] In fact, environmental mitigation through dietary changes that reduce livestock product consumption may benefit the environment at a scale not achievable by producers, providing evidence for the importance of dietary change (Poore and Nemecek, 2018[43]).

[26] Including the use of individual countries own guidelines for a balanced diet.

agriculture is an important share of economic activity or those related to the biofuel sector which are not covered in this report.

The value of the stylised scenarios in this report lies not in the specific estimates but in the general picture that emerges: namely, policy interventions or other changes affecting one dimension of the triple challenge may have important spill-over effects in other domains, whether positive or negative (trade-offs).

At the same time, not every spill over effect is large. The scenarios provide several examples in which effects in one dimension of the triple challenge may be low (such as a small decline in undernourishment), while large changes occur simultaneously in another dimension (such as a larger decline in obesity). Impacts across dimensions also do not always move in the same direction. One intervention may imply a synergy between two domains (for example, lower food prices and less undernourishment in Africa), while a different intervention would show a trade-off (for example, lower food prices and higher level of overnourishment in India) or have no effect beyond the targeted dimension (for example, lower level of overnourishment and no impact in number of undernourished in Latin America).

Significant challenges exist in addressing the dimensions of the triple challenge, and improved policies can play a role in addressing these challenges. This report shows that in designing policies which impact diets, potential synergies and trade-offs need to be taken into account. It may also require policymakers to balance competing objectives in their choice of policy instrument. Doing so will increase the analytical requirements, thus increasing the need to collect internationally comparable food information, such as those used in OECD countries (Table A A.1 in Giner and Brooks (2019[28]) for designing effective policies). For example, several studies revealed that because of the scarcity of standardized national data on food prices and environmental indicators, current diet sustainability may be under estimated. Particular attention should be paid to nutritional quality, which needs to be assessed through relevant macro and micro nutrient-based indicators, and to cultural acceptability, a key – although often ignored – dimension of sustainability (Perignon et al., 2016[31]). These gaps, may have hindered the analysis of the synergies and trade-offs between the three dimensions and could have had important implications for the choice of policy instrument and the level of intervention needed.

The changes in food consumption patterns needed to achieve each of the stylized scenarios are relatively large and significantly impact food supply, demand, trade, environment and prices. In addition, the imposition of such changes over a ten-year period should be considered illustrative only, as eating habits of consumers change slowly. As mentioned above, the implementation of policies to change dietary patterns would realistically result in smaller demand changes than those assumed in the stylized scenarios presented here. Besides the existing data gaps mentioned above, future model developments could improve the current framework by including a longer forecasting horizon, including an isocaloric compensation mechanism, providing a more detailed costs of production structure and include the modeling of specific policies intended to reduce consumption of sugars and fats. That said, in future work involving dietary changes, the triple challenge indicators developed for this paper will help in tracking synergies and trade-offs between the three dimensions of the food system.

Although these stylized results represent only a first step in clarifying trade-offs and synergies related to food systems policies, the results suggest that future food policies must consider both health and agricultural outcomes, thereby enabling the development of a coherent mix of policies that will ultimately benefit agriculture, human health and the environment (Kearney, 2010[32]). If designed carefully, policy packages to promote healthier diets by changing the level and composition of the food consumed could decrease both undernourishment and overnourishment, as well as lower GHG emissions and agricultural land use while maintaining farmers' livelihoods. More research is needed to explore how a package of policy instruments could be designed to mitigate the trade-offs and stimulate valuable synergies across the various dimensions of the triple challenge.

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Annex A. Methodology for under and overnourishment estimates

Among the indicators used to assess the scenarios are measures of under- and overnourishment. This section explains how the estimates are derived.

The overall methodology is adapted from (Tallard, Liapis and Pilgrim, 2016[33])and the FAO methodology for calculating the Prevalence of Undernourishment (Wanner, 2014[34]). In a nutshell, the construction of under- and over-nourishment indicators involves defining a (country- or region-specific) distribution function for dietary energy intake (DEI), which is then compared with a threshold for minimum dietary energy requirements to calculate the prevalence of undernourishment, and with thresholds for excessive energy intake to calculate the prevalence of overnourishment. These calculations require several inputs. The Aglink-Cosimo model can be used to calculate (country- or region-specific) dietary energy supply (DES), from which retail-level food waste is deducted to arrive at the dietary energy consumption (DEC), which corresponds to food purchased by consumers. Using the distribution of DEC together with consumer-level food waste,[27] it is then possible to obtain an estimated distribution of DEI. Comparing this distribution with thresholds for under and overnourishment (FAO et al., 2020[7]) then enables calculation of the prevalence of under- and over-nourishment. The remainder of this section discusses each of the elements in more detail.

To enable this assessment, several extensions to the model were required: inclusion of additional commodities to cover all food;[28] the mapping of food products to their calorie equivalent; and incorporating waste assumptions at the retail and household levels, including several indicators from the FAO Food Security Indicators and WHO Global Health Observatory data repository.

Defining under and overnourishment

The approach used here defines under- and overnourishment in terms of energy balance, i.e. the difference between food energy availability and energy expenditure. When the energy balance is disturbed, changes in weight can occur (FAO/WHO/UNU, 2001[35]). However, energy balance is not the only factor behind weight changes. These are caused by a range of factors, including genetic predisposition, socioeconomic status[29] and personal activity levels. This report does not attempt to project overweight or obesity (which are trend-based), but rather focuses on the variation from the baseline in the prevalence of overnourishment, defined as excessive food energy intake, as opposed to the concept of undernourishment and explained by one of the several factors contributing to weight change; the variation in food energy availability.[30] This approach was informed by an OECD literature review that identified different approaches to forecasting overweight and obesity (OECD, 2017[36]). The conclusion of the review supports the framework which assumes that food energy availability, minus waste levels, is loosely correlated with over and undernourishment (Figure A A.1). The nutritional quality of a diet, in particular its protein quantity and origin (plant or animal-based[31]) play an important role in keeping individuals healthy

[27] Undernourished individuals waste nothing at home therefore DEC = DEI at and below the MDER.

[28] Fruits and vegetables and other missing food commodities such as animals, cereals, and fat and non-fat dairy products which are not part of the major agricultural commodities usually covered in the OECD FAO Agricultural Outlook are introduced as an exogenous component of the model.

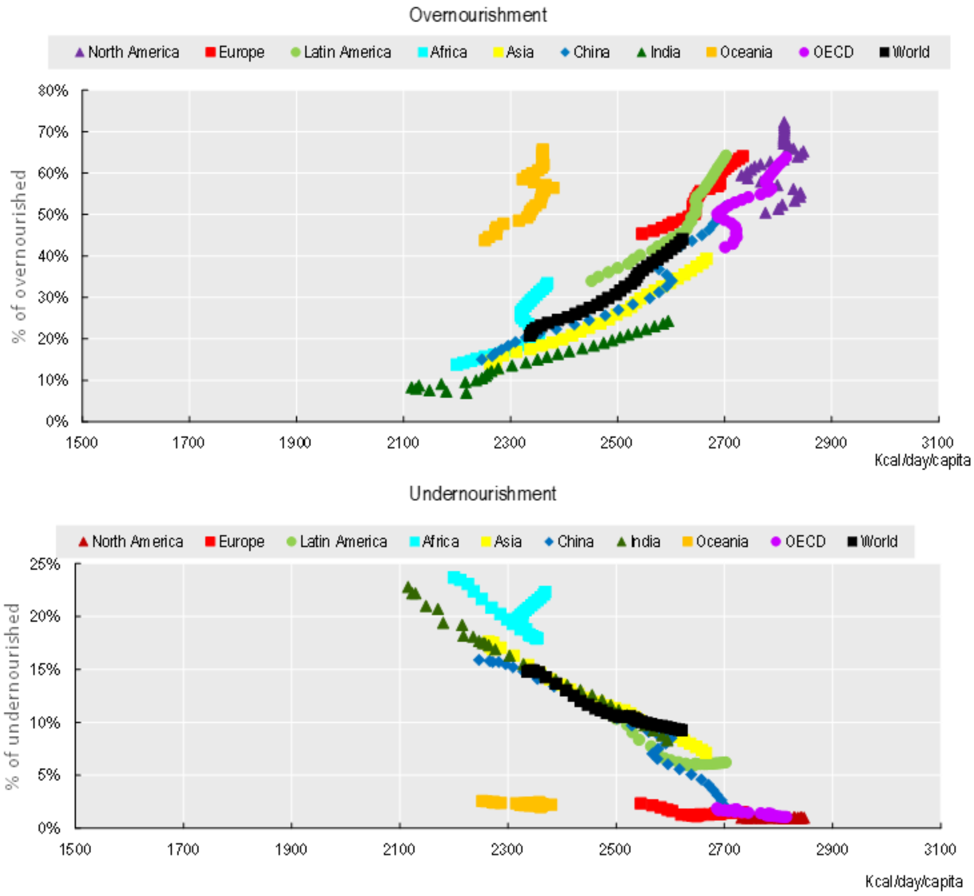
[29] For more information, see Placzek (2021[42]).

[30] Macronutrients, carbohydrates, protein, and fat are the elements used to calculate food calories.

[31] Plant proteins differ in nutritional quality and those who choose, especially in more vulnerable populations, to emphasize plant versus animal proteins need to be aware of these differences when planning an appropriate diet.

(Hertzler et al., 2020[37]). The deficiencies and qualities of micronutrients – commonly referred to as amino acids – vitamins, and minerals are not considered in this report. However, if there is inadequate food energy intake, micronutrients are also likely to be inadequate.

Figure A A.1. Share of over and undernourishment vs. daily energy intake, 2000-2030



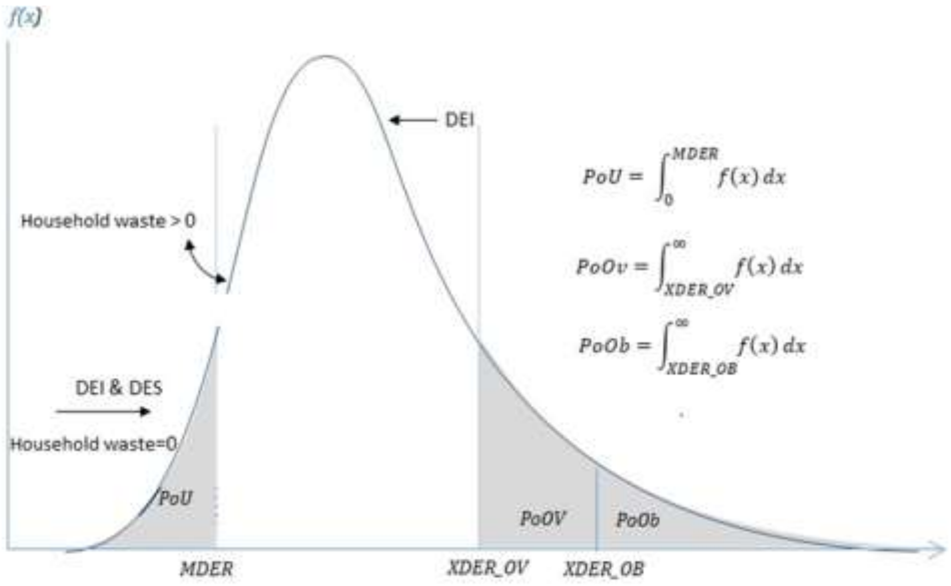
Source: Adapted from Cafiero (2014[21]).

Measurements of under- and over-nourishment follow a common approach based on (FAO/WHO/UNU, 2001[35]). They assume that an individual's daily access to food throughout the year is characterised by a distribution function *f(x)* describing an "average" person within the population in terms of age, sex, stature and level of physical activity. The distribution function as used by FAO in its estimates of undernourishment is described by a mean level of the DEC – i.e. after deducting estimated retail waste, a coefficient of variation parameter (CV) that accounts for inequality in food consumption, and a skewness parameter (SK) that accounts for asymmetry in the distribution. This report differs from the FAO approach only in how it defines the distribution in terms of DEI, i.e. after deducting estimated food waste at home, as discussed below.

FAO (2020[7]) provides data for energy thresholds in kilocalories (Kcal) to define the minimum and excess levels of caloric intake for each country. The probability of people falling under the minimum dietary energy requirement (MDER) threshold is categorised as undernourished, as indicated by the PoU; and the probability of people ranked above the excess level thresholds (XDERs) is categorised as overnourished, with a further distinction between the Prevalence of Overweight (PoOV) and the Prevalence of Obesity (PoOB), respectively (Figure A A.2).[32]

Historical and projected values for the minimum and excess thresholds of caloric intake are calculated and provided by FAO (2020[7]). FAOSTAT (2019[38]) also provides historical PoU data, while WHO 2019[33] historical BMI estimates greater than or equal to 25 can be used as approximations on the PoOv and BMI estimates greater than or equal to 30 approximates the PoOb.[34] The historical data, widely used as indicators to define over- and under-nourishment, are then extended using historical trends.

Figure A A.2. Framework for estimating the prevalence of under and overnourishment



Source: Adapted from Figure 1 of Cafiero (2014[21]).

The WHO defines overweight and obesity as abnormal or excessive fat accumulation that presents a risk to health; this definition uses body mass index (BMI) as an indicator (WHO, 2020[6]). BMI is calculated as a person's weight (in kilograms) divided by height (in metres) squared. The principal advantage of this measure is that it is simple to compute and communicate; however, BMI can be flawed in accurately determining fat levels, as it does not distinguish between weight associated with fat and weight associated with muscle. As such, the indicator should be interpreted with caution (WHO, 2000[39]).

[32] The prevalences are based on the definition of a probability distribution for the food consumption of the 'average individual' in the population. This distribution is used to estimate the probability of consumption at levels outside the range that can be considered normal for such 'average individual'. What must be stressed is that the distribution used to estimate PoU, PoOV and PoOB is not a representation of the empirical distribution of food consumption levels in the population. As opposed to any actual individual, only a range of dietary energy requirement can be associated with the 'average individual' of the population, which is a statistical construct reflecting the many differences that exist in the population, and only values outside such range can be considered inadequate or excessive (Cafiero, 2014[21]).

[33] WHO (2019), Data on BMI, http://apps.who.int/gho/data/node.main.A896?lang=en (accessed October 2020).

[34] PoU data by FAO (2019) refer to the aggregate of each country population, while historical data on PoOv and PoOb by WHO (2019) refer to the population aged five years old and above. For the purpose of this report, it is assumed that the distribution of consumption for these different reference groups are the same. In addition, for PoU values below 2.5%, the baseline assumes the minimum value of 1%.

As discussed in more detail below, the DEI values are derived from the baseline projections or the scenario results computed by the model. The projected prevalence of undernourishment and overnourishment in the baseline is based on historical trends. The projected CVs are used to best approximate the DEI distribution to the projected PoU over the baseline period. For the purposes of this report, it is assumed that food consumption for all countries is log normally distributed. Adjustment factors are used to correct for differences between the theoretical model approximation and both PoOV and PoOB data which are similar to that used in the model calibration (OECD, 2015[40]). In the analysed scenarios, all elements of the distribution are then held constant, while the PoU, PoOV and PoOB become endogenous (residual) and generate different outcomes.

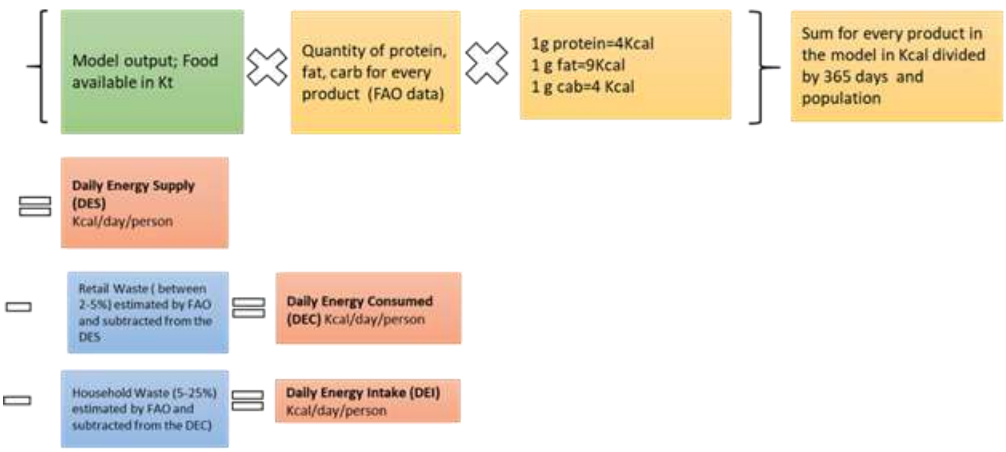
Dietary energy supply, consumption, and intake

The food supply database introduced by the baseline for historical and projected Dietary Energy Supply (DES), is expressed in kilocalories per capita per day.[35] This indicator represents the average caloric supply available for the population as a whole. The DES thus overestimates actual dietary energy intake as it does not take into account food waste at the retail level and at household level (Figure A A.3).

To account for this, DES is converted into DEC by removing waste at the retail level. Data regarding retail-level waste are provided by FAO estimates. In the scenarios, it is assumed that retail-level wastes remain fixed as a proportion of consumption.

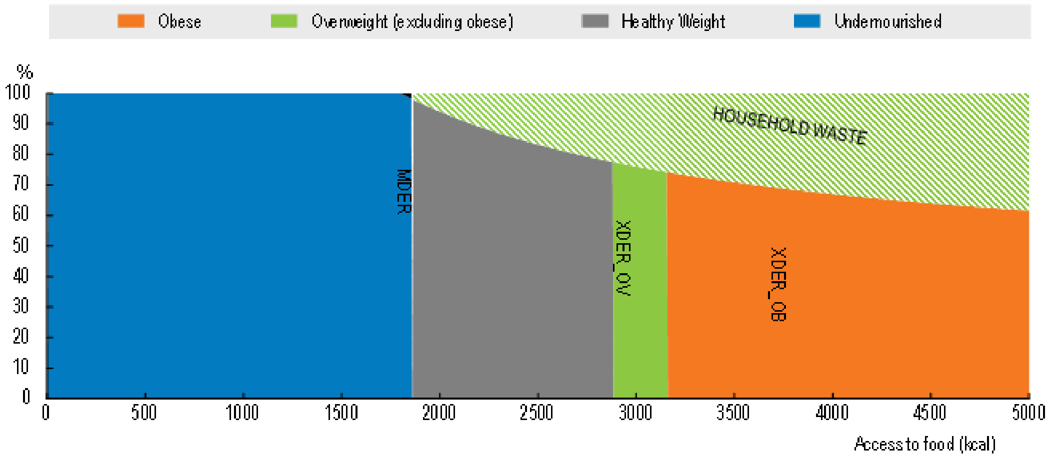
The next step is converting DEC into DEI by taking into account consumer-level food waste (Figure A A.3). A key assumption is that undernourished individuals will consume all available food at the DEC level and waste nothing at home (Cafiero, 2014[21]). That is, the rate of consumer-level food waste varies along the distribution. An estimate of this level of waste is necessary to correctly estimate the prevalence of overnourishment. Once individuals reach the MDER that provides sufficient energy to live a healthy lifestyle, an increase in DEC is assumed to go hand-in-hand with an increasing rate of consumer-level food waste, leading to a growing gap between DEC and DEI (Figure A. A.4).

Figure A A.3. Caloric supply, consumption and intake



35 The indicator is calculated in three-year averages to reduce the impact of possible errors in estimated DES due to the difficulties in properly accounting for stock variations in major food sources.

Figure A A.4. Schematic representation of the share of household waste based on consumer access to food

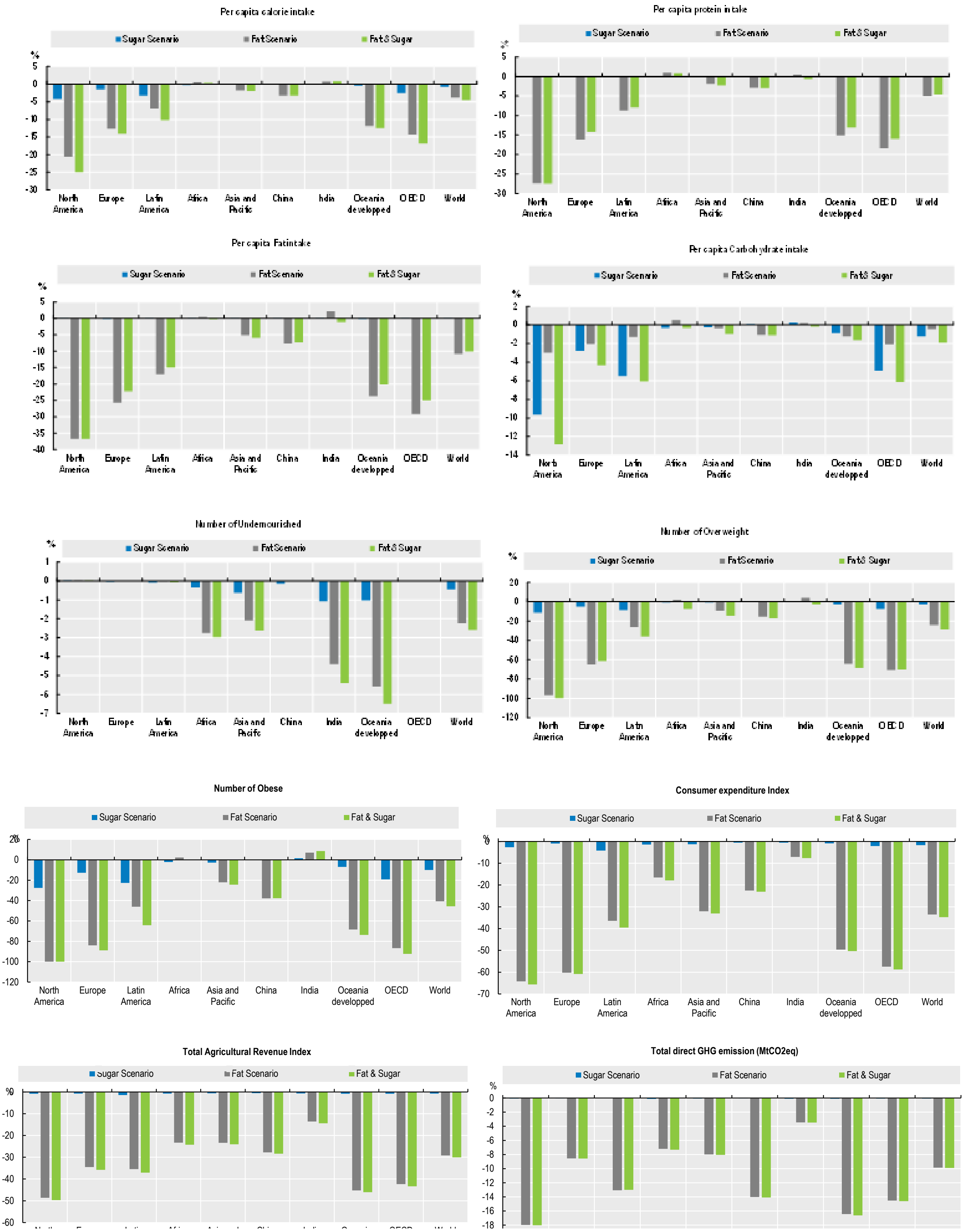


The percentage of total calories a household wastes is calculated based on the percentage of each commodity wasted weighted by that commodity's share in the household food basket by region. Household waste is endogenously calculated during the model scenarios simulation, taking into account food waste assumptions by commodity and regions (Gustavsson et al., 2011[41]).[36] Consumer waste remains proportional to consumption but varies depending upon the consumer's position within the distribution of food consumption (i.e. below or above the MDER).

In the baseline and scenario outcomes presented in this report, household-level waste changes according to dietary composition but remains a fixed proportion of each food component of the household food basket. In the three scenarios, the assumption that the level of waste for each commodity is fixed while the share of each commodity in the food basket may change can lead to an overestimation of the reduction in food consumption required to meet WHO dietary recommendations. In theory, consumers could change their waste levels rather than their consumption levels. This is unlikely, however, as it would imply that consumers are wasting more food simply to comply with WHO dietary recommendations.

[36] Waste estimates are in many cases based on assumptions and not direct estimates or measurements (Bagherzadeh, Inamura and Jeong, 2014[44]), (Gustavsson and Cederberg, 2013[18]). Data based on country-specific food waste measurements would improve model analysis.

Annex B. Implications of the three scenarios vs the baseline in 2030



Source: OECD analysis using the Aglink-Cosimo model.

Annex C. Indicator results for the three stylised scenarios

		Average	Growth[1]			
		2018-20est.	Baseline	Sugar[2]	Fat[2]	Sugar and fat[2]
Per capita calorie intake (Kcal/day/cap)						
	North America	2839	-1.0	-4.9	-20.5	-24.6
	Europe	2690	1.4	0.0	-10.8	-12.1
	Latin America	2647	1.9	-1.1	-4.8	-7.9
	Africa	2320	1.9	1.7	2.5	2.3
	Asia	2534	4.9	4.7	3.1	2.9
	China	2579	4.5	4.5	1.2	1.2
	India	2410	7.1	7.3	7.8	8.0
	Oceania	2344	0.7	0.2	-10.7	-11.1
	OECD	2783	0.9	-1.4	-12.8	-15.2
	World	2536	3.1	2.4	-0.5	-1.3
Per capita protein intake (g/day/cap)						
	North America	93	0.2	-0.1	-27.4	-27.5
	Europe	86	2.5	-0.2	-16.1	-16.3
	Latin America	75	2.6	-0.2	-8.7	-8.9
	Africa	61	0.0	-0.1	1.0	1.0
	Asia	73	4.1	-0.1	-1.9	-1.9
	China	86	4.7	-0.1	-2.9	-2.9
	India	62	6.8	-0.1	0.4	0.4
	Oceania	74	-1.6	-0.1	-15.1	-15.1
	OECD	88	1.6	-0.1	-18.4	-18.5
	World	73	2.2	-0.1	-5.0	-5.1
Per capita protein intake (Kcal/day/cap)						
	North America	373	0.2	-0.1	-27.4	-27.5
	Europe	343	2.5	-0.2	-16.1	-16.3
	Latin America	302	2.6	-0.2	-8.7	-8.9
	Africa	243	0.0	-0.1	1.0	1.0
	Asia	290	4.1	-0.1	-1.9	-1.9
	China	345	4.7	-0.1	-2.9	-2.9
	India	250	6.8	-0.1	0.4	0.4
	Oceania	297	-1.6	-0.1	-15.1	-15.1
	OECD	351	1.6	-0.1	-18.4	-18.5
	World	292	2.2	-0.1	-5.0	-5.1
Per capita fat intake (Kcal/day/cap)						
	North America	1193	1.0	0.9	-34.8	-34.8
	Europe	990	1.5	1.3	-23.6	-23.8
	Latin America	786	4.0	4.0	-13.1	-13.1
	Africa	416	2.0	1.9	2.3	2.2
	Asia	610	11.5	11.4	5.9	5.8
	China	725	10.3	10.2	2.1	2.0
	India	482	17.9	17.9	20.3	20.2
	Oceania	905	4.4	4.3	-19.3	-19.4
	OECD	1031	2.0	1.9	-26.6	-26.7
	World	658	5.7	5.6	-5.4	-5.5

		Average	Growth[1]			
		2018-20est.	Baseline	Sugar[2]	Fat[2]	Sugar and fat[2]
Per capita carbohydrate intake						
	North America	1274	-3.2	-11.9	-5.8	-14.8
	Europe	1357	1.1	-1.5	-0.9	-3.4
	Latin America	1560	0.7	-4.4	-0.5	-5.6
	Africa	1661	2.2	1.9	2.8	2.5
	Asia	1634	2.5	2.3	2.2	2.0
	China	1508	1.6	1.7	0.6	0.7
	India	1679	4.1	4.4	4.3	4.6
	Oceania	1142	-1.7	-2.5	-2.8	-3.5
	OECD	1401	0.0	-4.6	-1.9	-6.6
	World	1586	2.2	1.1	1.8	0.7
Number of undernourished (Mn)						
	North America	3.7	6.0	6.0	6.0	6.0
	Europe	10.0	13.1	13.1	13.1	13.1
	Latin America	39.5	10.3	10.3	10.3	10.3
	Africa	257.5	41.3	40.8	37.5	37.2
	Asia	479.9	-24.3	-24.8	-25.9	-26.2
	China	107.8	-64.1	-64.2	-64.1	-64.1
	India	185.4	-28.9	-29.6	-31.9	-32.6
	Oceania	0.9	4.5	3.5	-1.1	-2.0
	OECD	18.7	-17.3	-17.3	-17.3	-17.3
	World	791.5	-0.6	-1.0	-2.8	-3.1
Number of overweight (Mn)						
	North America	239.3	16.3	3.3	-96.0	-99.9
	Europe	429.6	9.8	4.5	-60.7	-68.7
	Latin America	346.7	28.4	17.5	-4.6	-21.8
	Africa	336.2	60.7	59.6	63.7	62.7
	Asia	1314.7	43.3	42.2	29.9	28.6
	China	527.6	40.2	40.2	19.2	19.3
	India	233.4	52.4	53.7	58.2	59.4
	Oceania	23.7	26.3	22.7	-53.5	-59.2
	OECD	781.1	15.7	7.3	-65.3	-72.7
	World	2690.2	35.7	31.6	3.6	-1.0
Number of obese (Mn)						
	North America	128.3	26.0	-7.7	-99.9	-100.0
	Europe	175.5	19.2	4.6	-80.1	-86.1
	Latin America	144.9	40.4	9.7	-22.8	-48.4
	Africa	119.2	69.5	66.1	73.3	70.0
	Asia	375.4	62.4	58.1	27.7	24.0
	China	135.2	65.5	65.8	4.5	4.8
	India	52.5	71.4	74.0	83.0	85.6
	Oceania	10.6	38.5	29.3	-53.5	-61.2
	OECD	343.4	26.7	3.1	-82.4	-89.8
	world	954.0	46.8	32.8	-11.2	-18.0
Consumer expenditure Index (real)						
	North America	1.1	-2.8	-5.2	-62.8	-64.2
	Europe	0.8	-6.3	-7.1	-60.3	-60.9
	Latin America	0.8	26.0	21.2	-16.7	-20.4
	Africa	1.2	90.2	87.7	61.5	59.2
	Asia	1.2	14.0	12.7	-19.6	-20.7

		Average	Growth[1]			
		2018-20est.	Baseline	Sugar[2]	Fat[2]	Sugar and fat[2]
	China	1.3	1.7	1.1	-19.3	-19.8
	India	0.8	17.2	16.6	9.3	8.7
	Oceania	0.7	4.3	3.5	-44.6	-45.3
	OECD	1.0	-2.0	-3.9	-55.7	-57.0
	world	1.1	17.9	16.1	-18.2	-19.5
Total Agricultural Revenue Index (real)						
	North America	0.9	2.2	1.3	-44.7	-45.8
	Europe	0.7	-2.8	-3.4	-33.8	-35.0
	Latin America	0.6	-5.2	-6.4	-36.7	-38.1
	Africa	0.8	14.3	13.5	-10.5	-11.5
	Asia	0.9	-1.4	-2.0	-22.6	-23.2
	China	1.1	-2.8	-3.3	-27.6	-28.2
	India	0.8	2.2	1.6	-11.1	-11.9
	Oceania	1.0	-0.9	-1.7	-43.4	-44.2
	OECD	0.9	-0.1	-0.8	-39.6	-40.6
	world	0.9	-0.2	-0.9	-27.1	-28.0
Total direct GHG emission ($MtCO_2eq$)						
	North America	393.1	2.0	2.0	-16.0	-16.0
	Europe	585.3	-0.5	-0.5	-8.7	-8.7
	Latin America	896.7	1.3	1.3	-11.9	-11.8
	Africa	602.2	4.3	4.2	-2.9	-3.1
	Asia	2449.5	8.9	8.8	0.5	0.4
	China	756.3	7.0	6.9	-7.4	-7.5
	India	771.9	8.1	7.9	4.4	4.4
	Oceania	183.6	3.7	3.6	-13.1	-13.3
	OECD	1218.1	1.0	1.0	-13.4	-13.5
	World	5110.4	5.2	5.1	-4.9	-4.9
Agricultural land use (Mn ha)						
	North America	466.8	-0.9	-0.9	-2.2	-2.3
	Europe	461.7	-0.5	-0.5	-0.9	-0.9
	Latin America	706.9	0.7	0.6	-0.4	-0.4
	Africa	1090.9	-0.2	-0.2	-0.3	-0.3
	Asia	1659.3	0.2	0.2	-0.1	-0.1
	China	516.8	0.3	0.2	-0.5	-0.5
	India	180.2	0.1	0.1	0.1	0.1
	Oceania	354.6	-2.5	-2.5	-3.4	-3.4
	OECD	1214.6	-1.2	-1.2	-2.1	-2.1
	World	4740.2	-0.2	-0.2	-0.7	-0.7

1. Growth rates over the coming decade refer to growth between 2018-2020 and 2028-2030.
2. Sugar, fat, fat and sugar represent the three stylised scenario.
Source: OECD analysis using the Aglink-Cosimo model.

Annex D. Aglink Cosimo model countries and regions above the WHO recommendations for sugar and fat calorie intake

Countries	Sugar scenario	Fat scenario
Argentina	X	X
Australia	X	X
Brazil	X	X
Canada	X	X
Chile	X	X
China		X
Columbia		X
European Union	X	X
Indonesia	X	
Israel		X
Japan		X
Kazakhstan		X
Korea	X	X
Malaysia	X	X
Mexico	X	X
New Zealand	X	X
Pakistan	X	X
Paraguay	X	
Russia	X	X
Saudi Arabia	X	X
South Africa	X	X
Switzerland	X	X
Turkey		X
Thailand	X	
Ukrainia	X	
United Kingdom		X
United States	X	X
Viet Nam	X	X
Regions		
LDC Sub-Saharan Africa	X	
Other Central, South America and Caribbean	X	
Other Near East	X	
Other North Africa	X	
Other Europe		X

List of countries by sub-region

LDC Sub-Saharan Africa	*Other Central, South America and Caribbean*
Angola	Antigua and Barbuda
Benin	Bahamas (The)
Burkina Faso	Barbados
Burundi	Belize
Central African Republic (The)	Bolivia (Plurinational State of)
Chad	Costa Rica
Comoros (The)	Cuba
Congo (The Democratic Republic of the)	Dominica
Djibouti	Dominican Republic (The)
Eritrea	Ecuador
Gambia (the)	El Salvador
Guinea	Grenada
Guinea-Bissau	Guatemala
Lesotho	Guyana
Liberia	Haiti
Madagascar	Honduras
Malawi	Jamaica
Mali	Nicaragua
Mozambique	Panama
Niger (The)	Puerto Rico
Rwanda	Saint Kitts and Nevis
Sao Tome and Principe	Saint Lucia
Senegal	Saint Vincent and the Grenadines
Sierra Leone	Suriname
Somalia	Trinidad and Tobago
Togo	Uruguay
Uganda	Venezuela (Bolivarian Republic of)
Other Near East	*Other North Africa*
Bahrain	Algeria
Kuwait	Libya
Jordan	Morocco
Iraq	Tunisia
Lebanon	
Oman	
Palestine, State of	
Qatar	
Syrian Arab Republic	
United Arab Emirates (the)	
Yemen	
Other Europe	
Albania	Moldova (the Republic of)
Andorra	Monaco
Belarus	Montenegro
Bosnia and Herzegovina	Republic of North Macedonia
Faroe Islands (the)	San Marino
Gibraltar	Serbia
Greenland	
Holy See (the)	
Iceland	
Liechtenstein	

Annex E. List of countries in regional aggregates

Region	Category	Countries
North America	Developed	Canada, United States
Latin America	Developing	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, PuertoRico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela (Bolivarian Republic of)
Europe	Developed	Albania, Andorra, Belarus, Bosnia and Herzegovina, European Union[1], Faroe Islands, Iceland, Monaco,Montenegro, Norway, Republic of Moldova, Russian Federation, San Marino, Serbia, Serbia and Montenegro, Switzerland, Republic of North Macedonia, Ukraine, United Kingdom
Africa	Developed	South Africa
	Developing	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Egypt, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra-Leone, Somalia,South Sudan, Sudan, Togo, Tunisia, Uganda, United Republic of Tanzania, Western Sahara, Zambia, Zimbabwe
Asia	Developed	Armenia, Azerbaijan, Georgia, Israel, Japan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan,Uzbekistan
	Developing	Afghanistan, Bahrain, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, Hong Kong China, Macao China, The People's Republic of China, Democratic People's Republic of Korea, India, Indonesia, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lao People's Democratic Republic, Lebanon, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Occupied Palestinian Territory, Oman, Pakistan, Philippines, Qatar,Korea, Saudi Arabia, Singapore, Sri Lanka, Syrian Arab Republic, Chinese Taipei, Thailand, Timor-Leste,Turkey, United Arab Emirates, Viet Nam, Yemen
Oceania	Developed	Australia, New Zealand
	Developing	American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, Marshall-Islands, Micronesia(Federated States of), Nauru, New Caledonia, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna Islands

1. Refers to all current European Member states except the United Kingdom.
Source: FAO, http://www.fao.org/faostat/en/#definitions.

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Comments are welcome and can be sent to tad.contact@oecd.org.